JUL 5 1911

THE FOUNDRY

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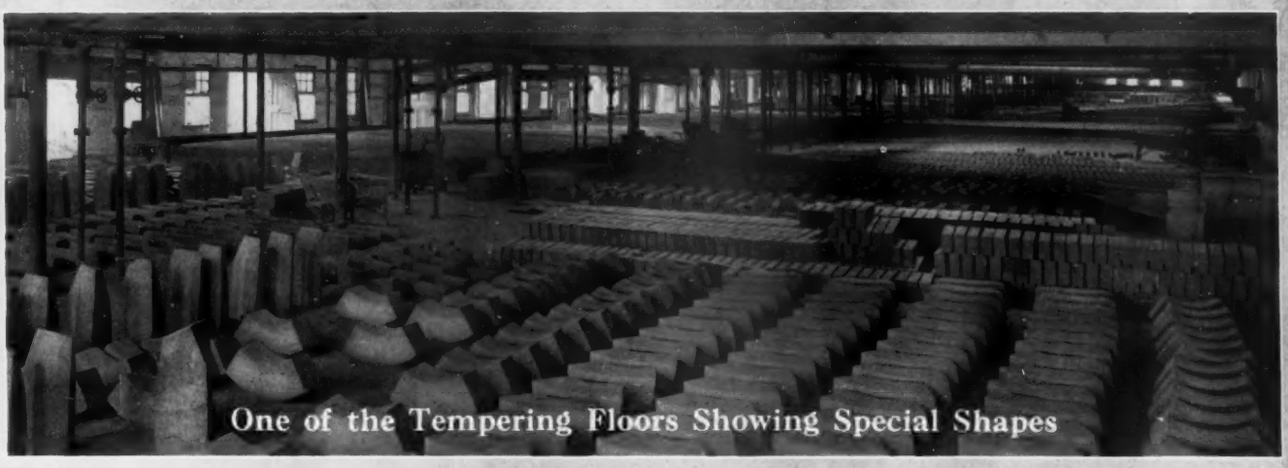

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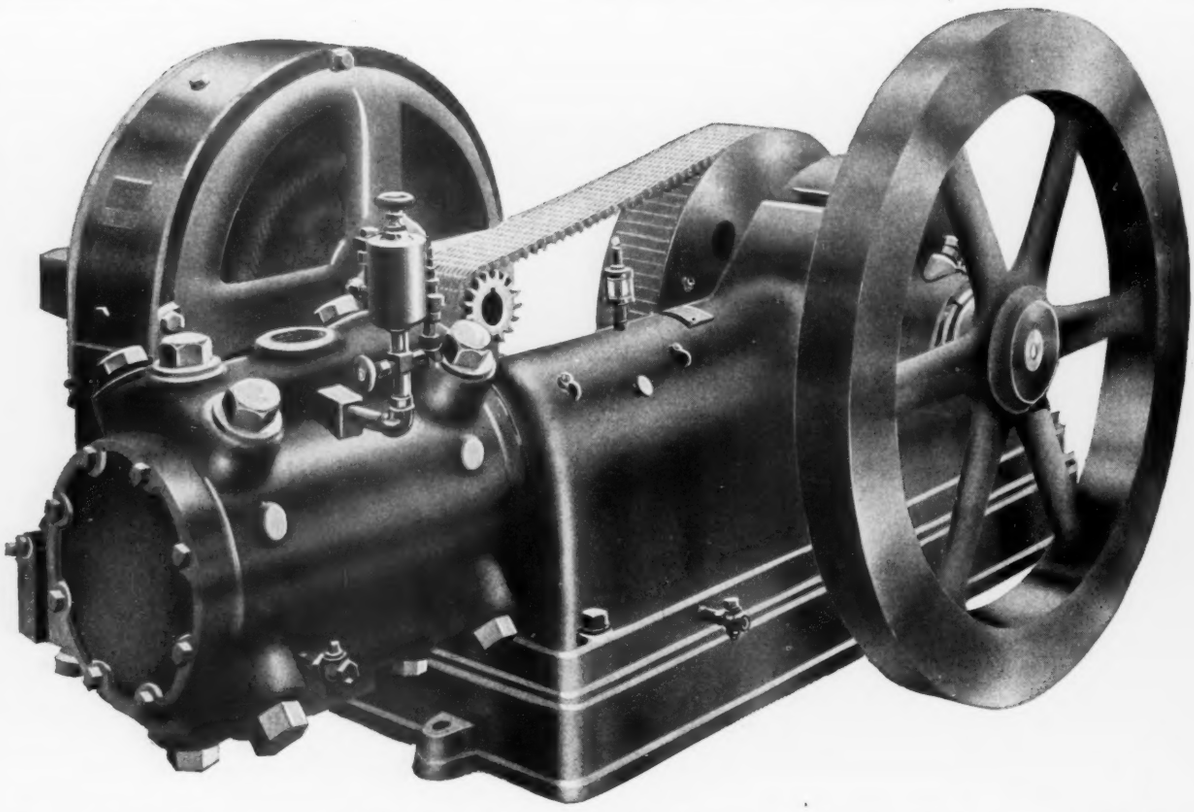

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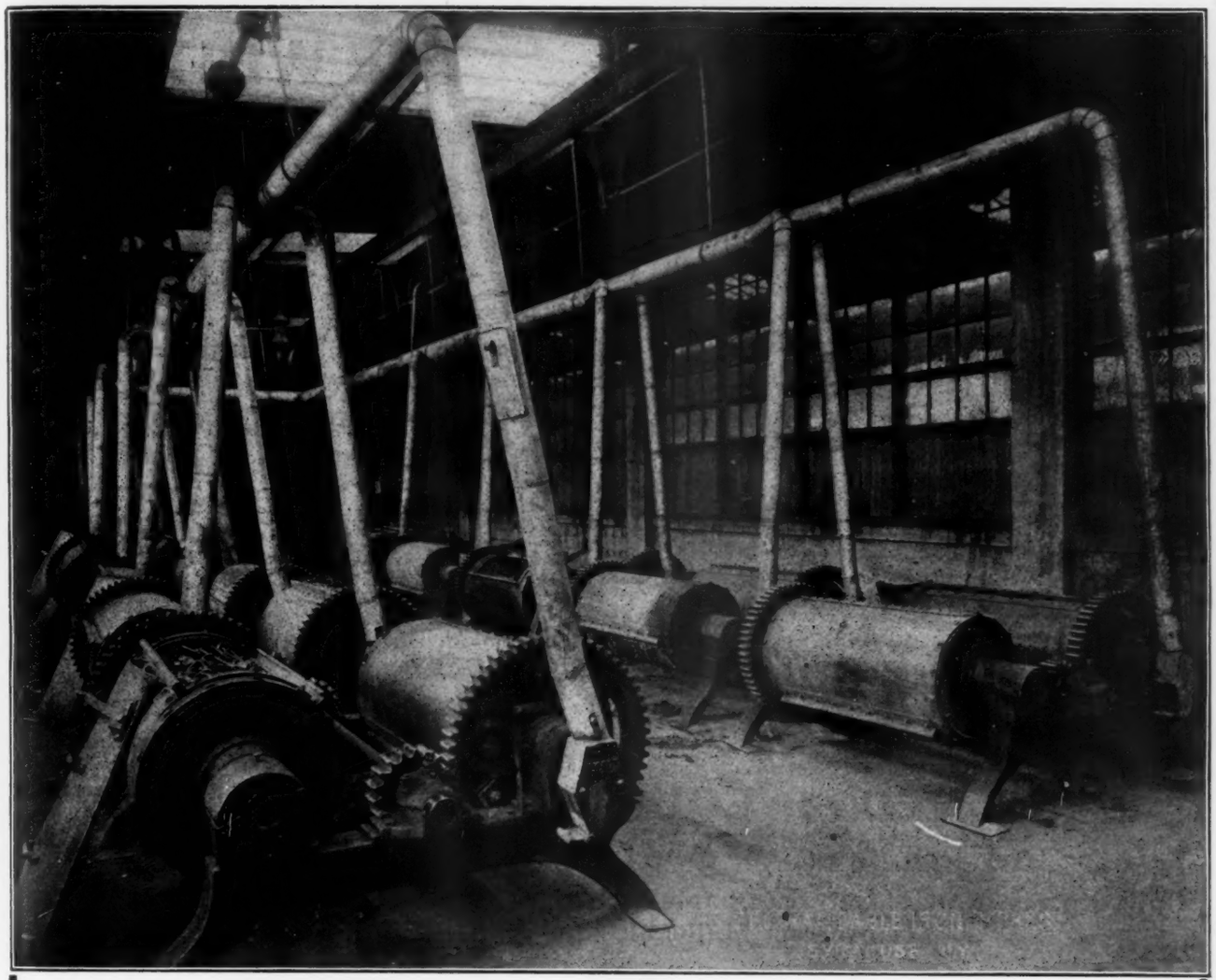

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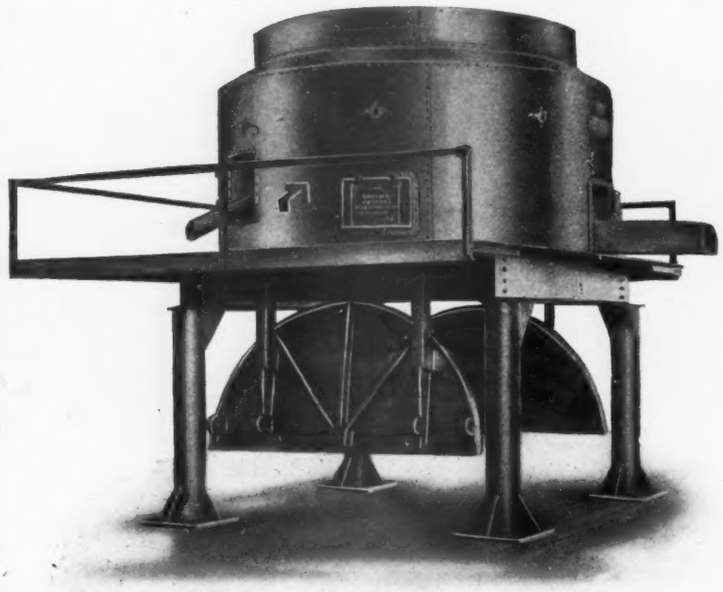

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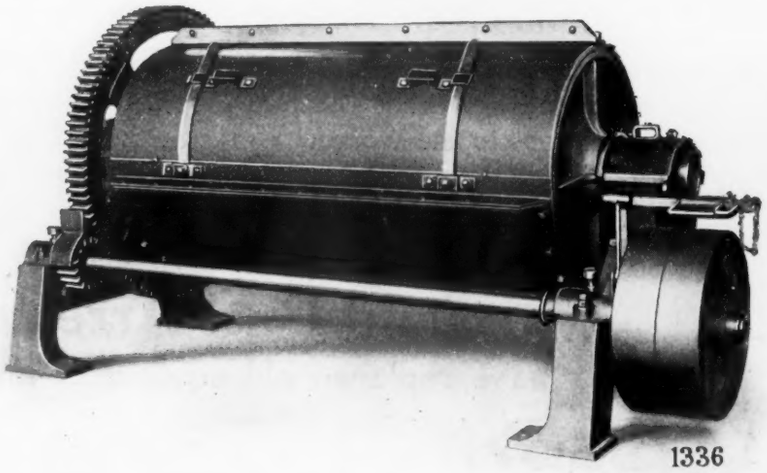

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See Page 103

THE FOUNDRY

Vol. 38, No. 5 Cleveland, Ohio, July, 1911 Whole No. 227

MODERN INDIANA GRAY IRON FOUNDRY

Description of the M. Rumely Co.'s plant, equipped throughout with labor-saving machinery that effects great operating economies

By H. Cole Estep

WHEN the history of foundry practice in the United States covering the period between 1850 and the present time is written, it will be the duty of the historian to point out the intimate relationship between the progress of gray iron practice and the development of the agricultural implement industry. It might even be stated that the enormous demand from implement makers for large quantities of intricate gray iron castings of all sizes has been a potent factor in the development of the modern gray iron shop. It is only natural, therefore, that many of the most highly developed gray iron foundries in the country are operated in connection with plants manufacturing agricultural machinery. The new foundry of the M. Rumely Co., La Porte, Ind., is one of the latest and most advanced shops of this class and has many features of noteworthy interest.

The Rumely foundry is notable for its refinement of detail, both in physical equipment and in organization and methods. It is one of a rapidly increasing group of plants which have been designed by men sufficiently familiar with the science of foundry administration to appreciate the advantages of a careful layout and the use of the latest labor-saving devices. Throughout the shop, from the storage yard where pig iron and scrap are handled by lifting magnets, to the cleaning room, which is equipped with special cranes and dust-collecting bins, elaborate mechanical appliances have been installed to take the place of hand labor. Most of the molding, including that for castings weighing a ton or more, is done by machine and even for the smallest castings none of the iron is carried or poured by hand. It is not, however, the abundance or cost of the mechanical equipment which makes this foundry notable, but the judicious manner in which the

FIG. 1—SOUTH BAY OF THE FOUNDRY, SHOWING MACHINE-MOLDED SNAP FLASK WORK

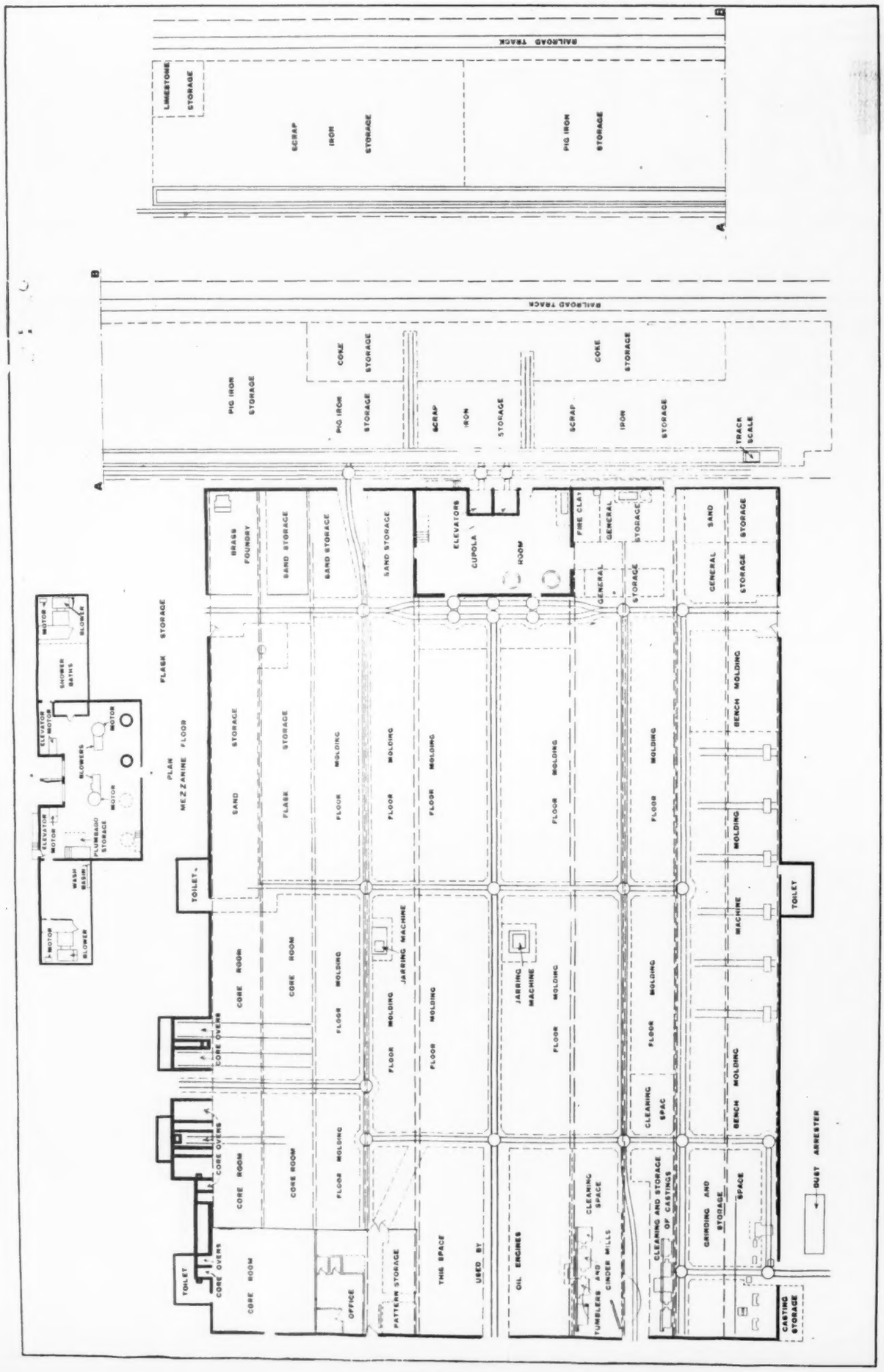


FIG. 2—ARRANGEMENT OF THE M. RUMELY CO.'S NEW FOUNDRY AT LA PORTE, IND., WHICH ALSO SHOWS A GROUND PLAN OF THE CHARGING AND MEZZANINE FLOORS

FIG. 3—GENERAL VIEW OF THE MAIN BAY OF THE FOUNDRY

machinery is disposed and utilized. The designer of the plant has endeavored to place each crane, molding machine or elevator in its proper place, where it will be made to contribute most to the productiveness of the shop. The heavy investment required to completely equip a large modern foundry involves a serious fixed charge which makes it imperative that the plant be designed to get the utmost out of its equipment and that a high order of intelligence be employed in its operation.

The M. Rumely Co. manufactures kerosene and steam-driven traction engines, separators, threshing machines, cultivating machines, etc. The castings vary from large crank cases weighing 1,800 pounds each to small engine parts averaging over a thousand to the ton. They are all made in the new foundry, which was designed for an output of 100 tons per day.

The building is a concrete and steel structure, 320 feet long and 220 feet wide, divided into five bays numbered for convenience in reference, as shown in Fig. 2. Work on the building was started June 7, 1910, and was completed Dec. 15, 1910, which is thought to be a record for rapid construction. The main bay is covered by a gabled monitor roof, and over each of the

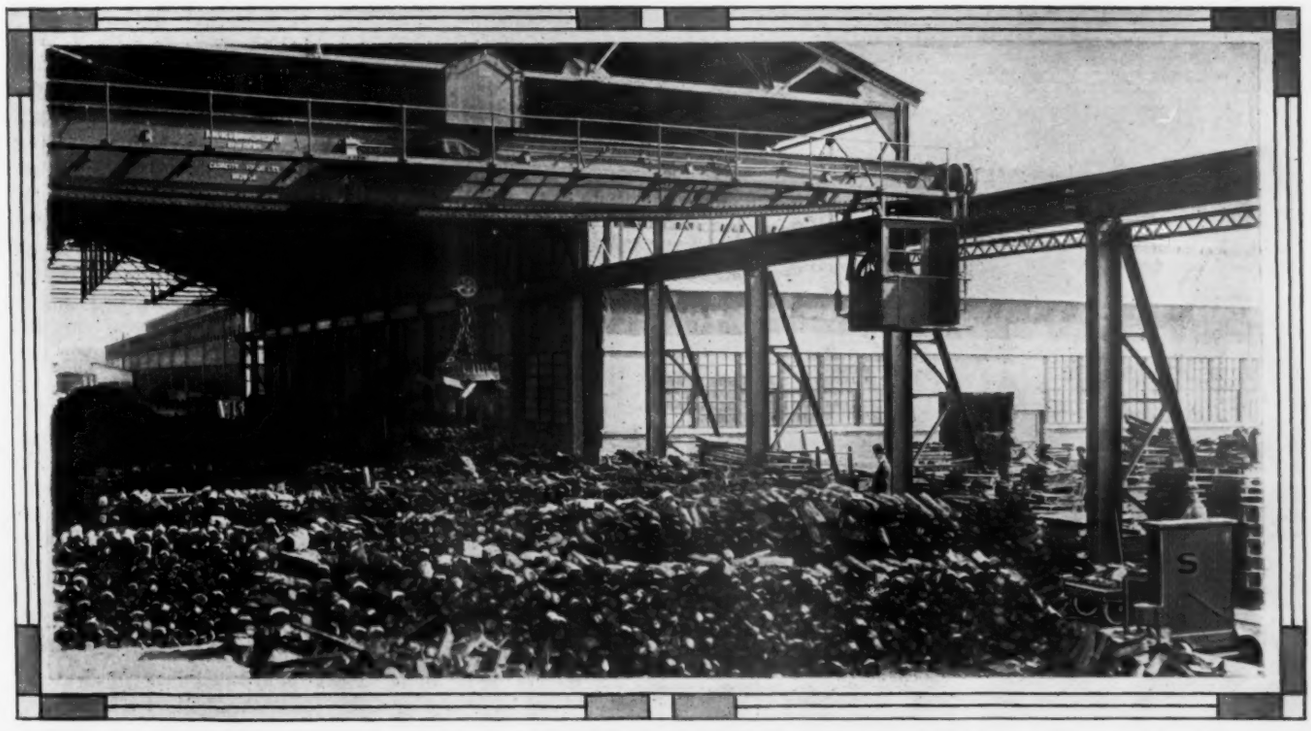
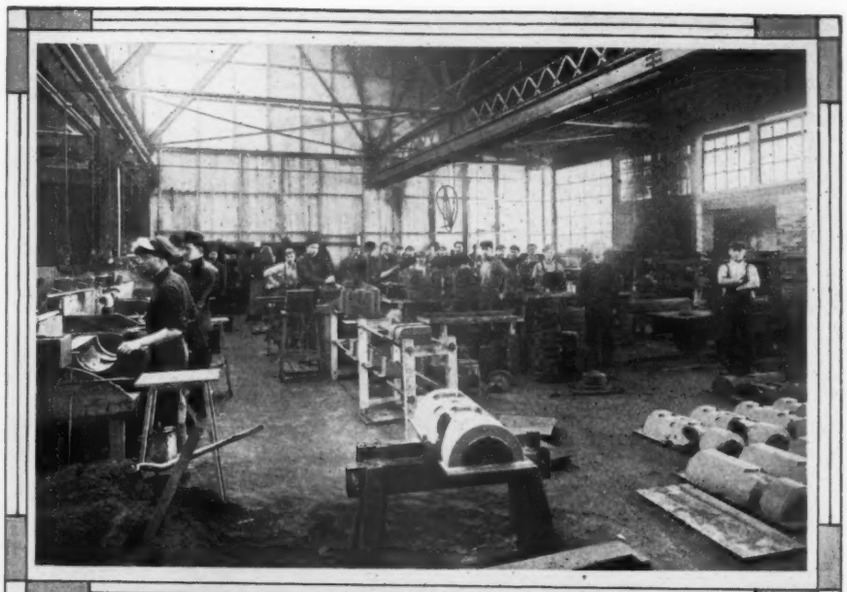
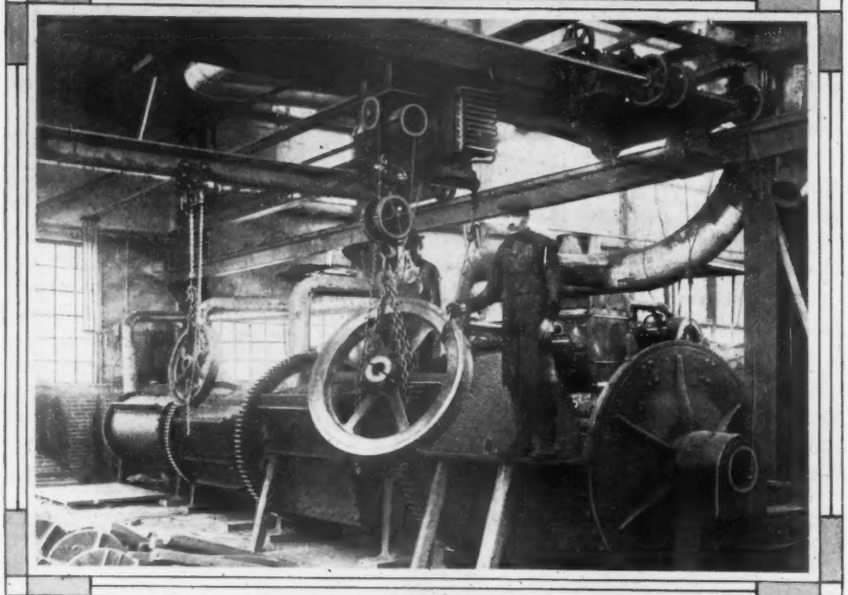


FIG. 4—THE PIG IRON AND SCRAP STORAGE YARDS





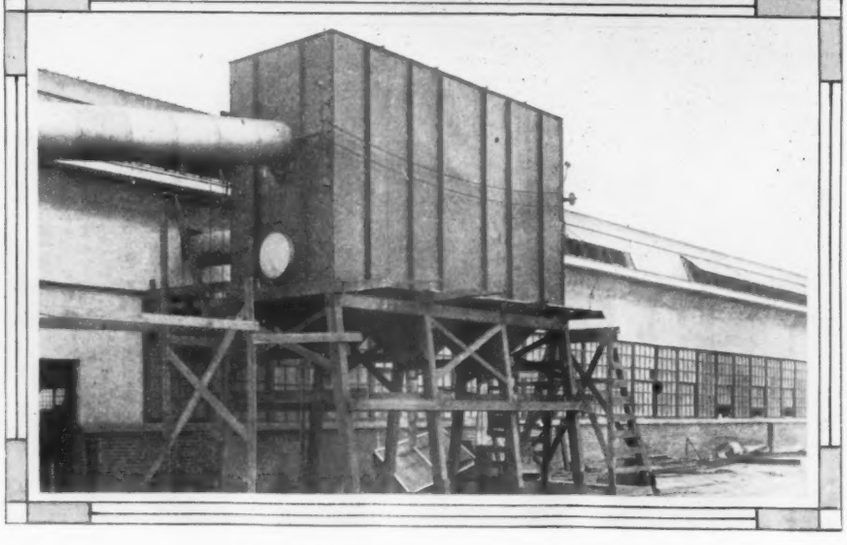


FIG. 5—A CORNER IN THE CORE ROOM

FIG. 6—CLEANING ROOM, SHOWING THE SMALL TRAVELING CRANES USED FOR LOADING AND UNLOADING CASTINGS

FIG. 7—DUST BINS FOR COLLECTING THE DUST FROM THE TUMBLERS AND GRINDERS

two side bays is a single gable roof supported by a row of posts in the center. The cupolas and charging floor are situated at the east end of the main bay. Bay No. 4, Fig. 1, on the south side of the shop, is devoted to bench molding and snap flask work on machines; bays Nos. 2 and 3 are used for light floor and machine molding; heavy floor and jarring machine work is done in the main bay, No. 1, and the core department occupies bay No. 5 on the north side. In designing the shop the old foundry, which had a capacity of 20 tons per day, was taken into consideration and it was found that it required 700 square feet of floor space per ton of output daily. This included the molding floor only. As continuous melting was to be practiced in the new foundry, it was decided that some of the molding floor could be used more than once the same day, by shaking out the molds that were poured early and ramming the flasks again in the same place, this being made possible by the extensive use of molding machines. The total area of the molding floor was, therefore, fixed at approximately 36,000 square feet.

Use of Squeezers.

Practically all of the snap flask work is machine-molded and the details of this process form one of the most interesting features of the operations of the shop. Tabor squeezers, Fig. 8, provided with patterns mounted on plates, are employed. Six machines are installed in bay No. 4, a general view of which is shown in Fig. 1. As indicated in Fig. 2, and shown in more detail in Fig. 8, each machine is mounted on a low car or truck which operates on a track laid across the floor. The molding sand is piled parallel to the track. When he commences his day's work, the molder draws the machine back to the outer end of the track and as the sand is used, moves it gradually toward the wall. The finished molds are laid in the space left by the removal of the sand. The molder takes no unnecessary steps and is able to work a great deal faster than if the machine were stationary. The man at the machine in Fig. 8, with only three weeks' experience, made molds, similar to those shown, at the rate of 16 per hour. There were two small castings in each mold which required no core setting.

Medium heavy work, such as pulleys, are molded on Pridmore stripping plate machines, as shown in Fig. 10. This class of work is put up in neat, specially made, round, cast iron flasks. Attention is called

to the cast taper lugs on the flasks shown in Fig. 10. Making 15-inch pulleys on machines similar to the one shown, an average production of 55 molds per day is obtained.

Jar-Ramming Machines.

Two jarring machines are installed at points indicated in Fig. 2. The larger one in the main bay, Fig. 9, is a 24-inch cylinder Norcross machine used for making crank case, fly wheel and other heavy molds. In this illustration a crank case mold is shown on the machine. This casting weighs 1,800 pounds. Three molders and two helpers are employed for making the mold, which is completed in about two hours. Both copes and drags are rammed on the jarring machine. Without the machine, two molders and a helper were formerly employed an entire day on a single mold. One molder and a helper formerly made by hand one fly wheel mold, about 4 feet in diameter, per day; now one molder and three helpers make five per day on the machine. The smaller machine in bay No. 3 was built by The Tabor Mfg. Co., Philadelphia. It has an 8-inch cylinder and is used for medium heavy work.

Large gears are molded from solid patterns by hand in circular flasks, similar to those in the foreground in Fig. 3. The cope halves of the gear patterns are mounted on boards and are drawn from the sand by the crane; the drag patterns are drawn by hand. The gears are rammed by hand.

Pouring the Molds.

Each molder pours his work from a 700-pound crane ladle, but is not required to shake-out flasks or cut-over the sand. It requires about seven minutes to pour out a ladleful of iron, after which the molder returns to his work. The shop operates on a 10-hour daily schedule and practically all the work is paid for on a piece rate basis. The piece rates are fixed by the foundry superintendent after careful study and comparison. Great care is used in fixing rates to arrive at equitable figures.

Foundry Instructor.

Each of the four molding bays is under the supervision of an instructor, who is a man of wide foundry experience. It is his duty to show the men short cuts and proper methods of doing work and to aid in every way toward getting a maximum production with least effort. It is also the duty of the instructor to route the work in his department so that each man will be kept busy at the kind of work for which he is best adapted

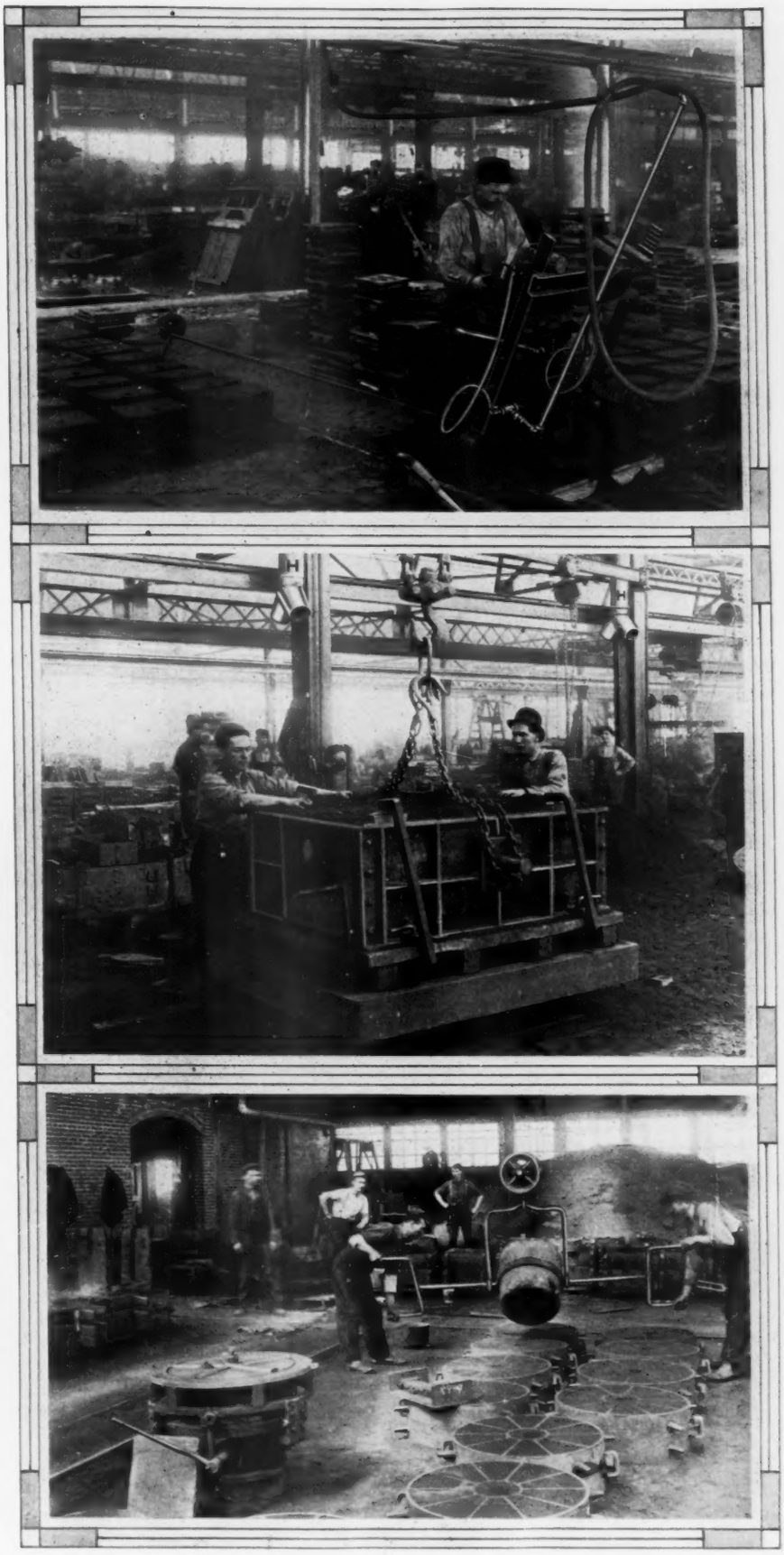


FIG. 8—ONE OF THE SQUEEZERS MOUNTED ON A TRUCK, WHICH OPERATES ON A TRACK

FIG. 9—ONE OF THE JAR-RAMMING MOLDING MACHINES, SHOWING A CRANK CASE MOLD ON THE TABLE

FIG. 10—STRIPPING PLATE PULLEY MOLDING MACHINE AND THE METHOD OF POURING PULLEY MOLDS

FIG. 11—ARRANGEMENT OF THE CUPOLAS, SHOWING ONE OF THE LADLE TRUCKS AND THE TRACKS FOR HANDLING THE HOT METAL

and to check up the production and progress of orders in his department. Thus, as far as organization is concerned, there are four small shops instead of one large foundry and each department thereby receives the personal attention which it is possible to give to a small shop. The foundry superintendent, of course, has general supervision of all departments.

At present the plant is melting about 70 tons daily, and employs 235 men, 65 of whom are molders. This gives an output of 1.08 tons per molder per day. The men are hired without regard to previous experience. New men are recruited from the smaller towns or from farms, as far as possible.

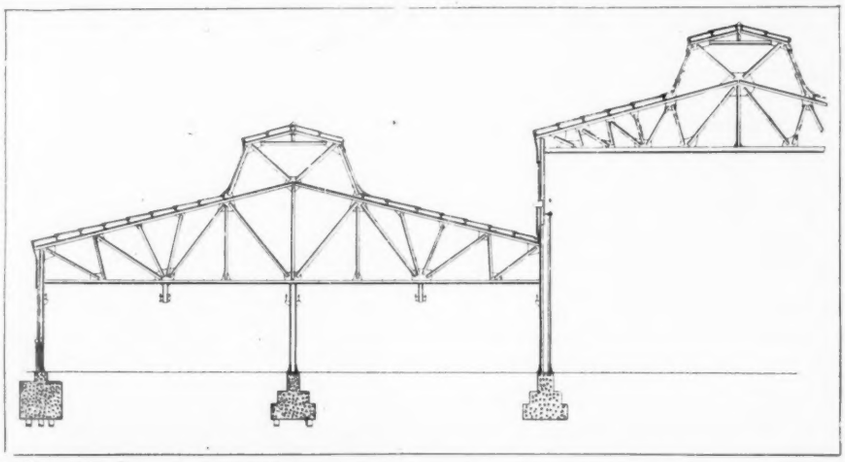


FIG. 13—TYPICAL CROSS-SECTION THROUGH PART OF THE FOUNDRY BUILDING, SHOWING STEEL STRUCTURAL WORK AND FOUNDATIONS

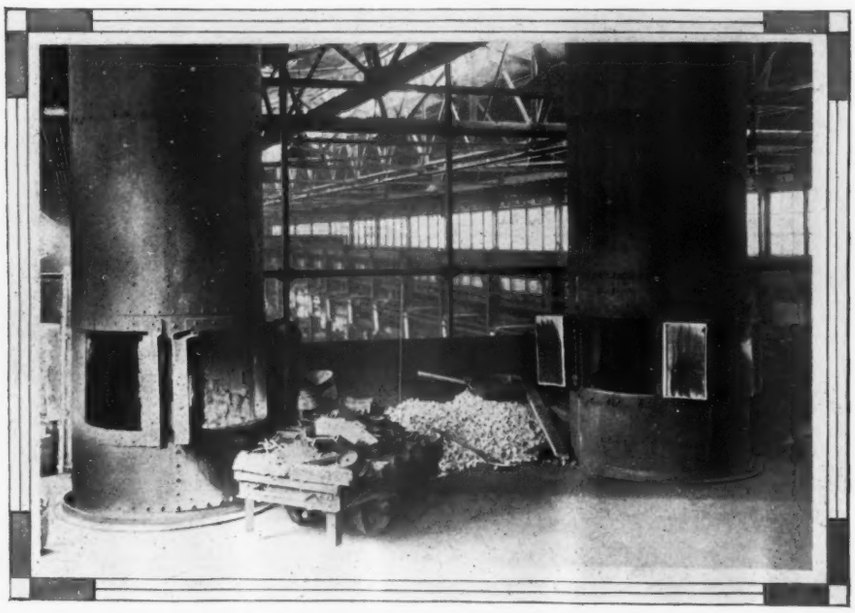


FIG. 12—CHARGING FLOOR, SHOWING TYPE OF CHARGING BUGGY

The pig iron, scrap and coke storage yard lies east of the foundry with its long axis perpendicular to the main axis of the shop, as shown in Fig. 4. Just east of the plant is a small prairie lake and the ground on which the shop is built is artificially filled. The building columns are placed on concrete footings which in turn rest on piles, as shown in Fig. 13. This illustration also shows the details of the roof trusses, windows, walls, and other structural features of the building. The columns throughout the shop are spaced 20 feet, center to center. In the old shop they were 16 feet and this proved insufficient for convenient operation. The walls are brick to the window sills and reinforced concrete above the windows. The monitor walls are also reinforced concrete while the roof consists of concrete slabs laid on steel purlins. The windows have steel sashes. Approximately 40 per cent of the wall space and 30 per cent of the roof is glass.

Heating and Lighting.

The shop is heated by direct radiation from steam coils and also by hot air distributed through the ventilating system. The steam coils are located above the crane rails and two of the hot air outlets are shown at H, Fig. 9. In the summer cold, fresh air is delivered through the ventilator system.

Artificial light is supplied by flaming arcs hung 40 feet above the floor in bay No. 1, and 15 feet above the floor in the side bays. In the main bay the lamps are provided with deep, concentrating reflectors, while those in the side bays have flat, diffusing reflectors. Each lamp illuminates approximately 2,400 square feet of floor. Six-ampere, regenerative, flaming arc lamps are used.

Payment will be made for all contributions on foundry and pattern shop practice suitable for publication.

FORMULAS FOR THE BRASS FOUNDRYMAN.

The addition of a small amount of manganese-copper is frequently advantageous in yellow alloys, as it eliminates surface pin holes in yellow brass castings, closes the grain and imparts a pleasing brown color to the castings. The following alloys are recommended:

No. 1—Yellow Brass.

	Pounds.	Ounces.
Copper	66	12
Manganese-copper	0	4
Zinc	30	0
Lead	3	0

No. 2—Yellow Brass.

	Pounds.	Ounces.
Copper	70	0
Manganese-Copper	0	8
Zinc	25	0
Tin	1	8
Lead	3	0

Lamp Bronze.

	Pounds.	Ounces.
Copper	76	0
Zinc	18	0
Tin	3	0
Lead	3	0
Manganese-Copper	0	2

Manganese-copper should be added to the metal after the copper is melted, and should be stirred in well, the surface of the copper being covered with a layer of charcoal. The zinc is next added, followed by the tin and lead. Manganese-copper should contain no iron, and as the content of manganese in the copper may vary, the quantity used in the alloys may be increased or decreased, if the amount given in the formulas does not give the required results. The best results from the use of manganese are obtained when the castings possess a light brown skin. If the color is sufficiently deep to injure the appearance of the castings, it will in all probability cause cold shuts; in this case the quantity should be reduced. If no external indication of the presence of manganese is visible, it may be advisable to increase the amount added to derive the full benefits of its use.

A mixture for a soft, ductile, yellow brass that can be riveted, follows:

	Pounds.
Copper	68
Zinc	30
Lead	2

DATA SHEET No. 93, THE FOUNDRY, JULY, 1911.

Note—This sheet may be cut into two sections, 5 x 7 inches, and may be readily bound in note-book form.

FORMULAS FOR THE BRASS FOUNDRYMAN.

The following alloys are well adapted for the requirements of electric railway service, and were originally included in the specifications for material by the mechanical department of the Transit Development Co., New York.

Bearing Metal*.

NEW METAL MIXTURE.	Pounds.	NEW METAL AND SCRAP MIXTURE.	Pounds.
Copper	77	Copper	38½
Tin	8	Tin	4
Lead	15	Lead	7½
		Scrap	50

*Maximum impurities allowed, 1 per cent. No. 1 Bearing Metal is used for axle, journal and motor bearings, check plates, etc.

Bronze*.

NEW METAL MIXTURE.	Per cent.	NEW METAL AND SCRAP MIXTURE.	Per cent.
Copper	88.40	Copper	62.00
Tin	5.50	Tin	3.80
Lead	2.80	Lead	1.90
Zinc	3.30	Zinc	2.30
		Scrap	30.00

*Maximum impurities allowed, 1.5 per cent. No. 2 Bronze is used for trolley wheels, car trimmings, trolley harps, and such power house castings as key heads, glands, keeper hooks, pump valves, oil and grease cups and all castings except bearings.

Bell Metal*.

	Pounds.
Copper	82
Tin	18

*Maximum impurity allowed, 1.5 per cent. This alloy is made of all new metals, no scrap being specified. Its use is confined to signal bells.

Steam Metal*.

NEW METAL MIXTURE.	Pounds.	NEW METAL AND SCRAP MIXTURE.	Pounds.
Copper	85	Copper	59½
Tin	5	Tin	3½
Lead	5	Lead	3½
Zinc	5	Zinc	3½
		Scrap	30

*Maximum impurities allowed, 1.5 per cent. This alloy is used for all castings for steam fittings.

Common Brass*.

	Pounds.
Copper	67
Zinc	33

Scrap, up to 100 per cent.

*Maximum impurities allowed, 1.5 per cent. Common brass is used for miscellaneous castings, such as the various meter and controller parts.

All scrap must be of the same composition as the alloy with which it is to be mixed, and where the amount of scrap specified cannot be obtained, new metals must be used alone.

DATA SHEET No. 94, THE FOUNDRY, JULY, 1911.

There is no supplementary illumination except in the core room, where a 16 candle power incandescent lamp is hung over each bench. The most suitable type of illuminating units and their proper spacing were determined by test and comparison. Experiments were made with various kinds of lamps in a smoky atmosphere similar to that which often exists in a foundry and the yellow beam from the flaming arc appeared to be the most penetrating.

Air compressed to 90 pounds per square inch at the main power plant of the works is supplied in abundance to all parts of the shop for the operation of various pneumatic machines. The air lines are carried between the crane rails and the posts at the side of each bay and branches are tapped in every few feet as shown at *B*, Fig. 1.

Date_____ Pat. No._____ Order No._____

Name of Casting_____

Kind of cores in casting_____ Wt._____

No. of cores in casting_____

No. castings wanted_____ Send to Dept. No._____

Molder_____

Remarks_____

Foreman_____

The Foundry

FIG. 15—CLEANING ROOM ORDER

Protected Storage Yard.

The storage yard, Fig. 4, is at the east end of the plant just back of the cupolas. The yard is 73 feet wide and 500 feet long. A portion of the yard, 300 feet in length, nearest the shop, is covered by a gable roof. The roof is not absolutely necessary but the protection it affords makes it much easier to handle material in the winter. The yard is served by a 5-ton Pawling & Harnischfeger crane equipped with a lifting magnet for handling pig iron and scrap, installed by the Electric Controller & Mfg. Co., Cleveland. Along the east side of the yard extends a standard gage track over which cars loaded with material are switched in. On the west side, next to the shop, as shown in Fig. 2, is a narrow gage, sunken track equipped with a self-propelled electric scale car shown at *S*, Fig. 4. Parallel to the sunken track is a narrow-gage surface track, connecting with the industrial railway and the charging floor elevators. This is used for the storage of cupola charges, thus making it possible to use a smaller charging floor and preventing any trouble due to delays in delivering material to the cupolas during a heat.

MOULDING ROOM ORDER

M. RUMELY COMPANY

Fdy. Order_____

Material_____ Patt. No._____

Name of Cstg._____

Pcs. wanted per day_____ Del. to_____

Remarks_____

Sig._____

The Foundry

FIG. 14—MOLDING ROOM ORDER

The charging floor, Fig. 12, is 40 x 60 feet, supported on I-beams. A smooth, rigid surface is provided by a course of steel channels laid flange to flange, backs up. Good ventilation is secured by leaving open the front end of the floor facing the main aisle, protecting it only by a low guard fence, as shown. The elevators, two in number, are at the back nearest the storage yard. Each elevator is 8 x 8 feet, and of 5 tons capacity. Two cupolas are installed, each being 48 inches in diameter inside of lining. One was built by the Whiting Foundry Equipment Co. and the other by the Calumet Engineering Co., Harvey, Ill. One of the features of the cupolas is the height between the bottom plates and charging doors, which is 22 feet. A melting ratio of 9 to 1 is obtained. One cupola is run on gray iron and the other produces semi-steel.

The gray iron mixtures are standard, made up by analysis. The semi-steel mixtures vary somewhat accord-

M. RUMELY COMPANY

CORE ROOM ORDER

No._____

Patt. No._____

Make_____ Cores from Core Box No._____

Clock No._____ Name_____

DATE	CORES MADE	IMPERFECT		PERFECT	DUE	DATE	CORES MADE	IMPERFECT		PERFECT	DUE
		MAKER'S	CO.'S					MAKER'S	CO.'S		

Date_____ (Sig.)_____

The Foundry

FIG. 16—CORE ROOM ORDER

ing to the work to be cast, but do not diverge far from the following, which has been found successful for ordinary work:

Steel scrap .....20 to 25 per cent
Selected No. 1 gray iron scrap 15 per cent
No. 2 pig iron .....65 to 60 per cent

The charges weigh 1,000 pounds each; larger charges have caused trouble in the operation of the cupola, particularly on semi-steel. The reason for this seems to be that the material melts unevenly unless charged in comparatively small quantities, so that it is thoroughly mixed. Steel does not melt like pig iron, but first becomes pasty before liquefying and if heavy rounds are charged the resulting metal at the spout will lack uniformity of composition. In making up semi-steel charges due account is taken of the influence of the coke on the bath, since the experience at this plant indicates that some of the carbon in the coke is dissolved in the metal. Mixtures have been charged that were calculated to give 2.25 per cent carbon, but an analysis showed 3.40 per cent in the metal at the spout. The inference is that the additional carbon is taken up from the coke.

Handling the Hot Metal.

The arrangement of the cupola spouts and the provisions for handling hot metal are shown in Fig. 11. A low brick wall protects the legs of the cupolas and keeps the heat and smoke from the drop, out of the shop. The iron is all poured into 2,000-pound truck ladles similar to the one shown at the right in Fig. 11. As fast as these ladles are filled they are switched onto the storage track parallel to the pouring track or run out on the track which extends down each aisle. From the truck ladles the iron is poured into 700-pound ladles which are picked up by the cranes and the molds are poured as shown in Fig. 10. No iron is carried by hand. This arrangement does away with the time-honored receiving ladle under the spout, but permits the iron to be poured cleaner, quicker and consequently, hotter. Each molder pours his own work. The fire in the cupolas is started by a torch burning crude oil under pressure, the burner being placed in the spout so that the flame is directed through the tap hole.

As indicated, the plant has unusually complete facilities for the transportation of materials. Each bay is provided with overhead traveling cranes and also with industrial tracks. The cars are all built with the wheel flanges running on the outside instead of on the inside of the rails and since the track is elevated slightly above the general level of the floor, there is no trouble in keeping the flangeways clear. With ordinary cars having flanges on the inside, constant work is necessary to keep the passage for the flanges clear, otherwise it becomes difficult to move the trucks and derailments are frequent. The trucks are all of the four-wheel variety and are pushed by hand, using one or two laborers as the case requires. Occasionally the tracks are sprinkled to settle the dust and aid in keeping the rails clean, and this is all the attention which they require. The molding sand, which is stored at the east end of bay No. 5, as shown in Fig. 2, is distributed in ½-yard buckets by means of the industrial railway, supplemented by crane service. In the foreground of Fig. 3 a load of sand ready to be picked up and dumped by the crane may be seen. The sand buckets are provided with bails for ease in crane-handling.

The central bay is equipped with a 57-foot, 7-inch span, 10-ton Pawling & Harnischfeger electric traveling crane provided with a 3-ton auxiliary hoist. This bay is also provided with I-beam jib cranes equipped with hand hoists and trolleys as shown at the right in Fig. 3. Each aisle in the side bays is provided with a 20-foot span, 2½-ton Whiting foundry crane, equipped with ground control. These cranes are used for a large variety of purposes. In Fig. 6 one may be seen unloading heavy fly wheels from the tumbling mills. This illustration also shows one of the 1-ton hand cranes which are used for light work in the side bays, supplementing the electric cranes. Fig. 10 shows how the 2½-ton Whiting cranes are used in pouring, handling 700-pound crane ladles.

SYMBOL NUMBER

M. RUMELY COMPANY

FOUNDRY ORDER

ORDER No.

Cast_____Name of Casting_____

DATE	PCS. CAST	DUE	DATE	DEP'T	PCS. DEL'D	TOTAL DEL'D	RECEIVED BY	SCRAP DATE	SCRAP PCS.	ON HAND

The Foundry

FIG. 17—FOUNDRY ORDER SHEET

Core Department.

The west end of bay No. 5 is fitted up for coremaking. Five car ovens, 7 x 15 feet, and four shelf ovens, as shown in Fig. 2, are installed. The ovens are built outside the building and are fired from the outside. Approximately 8,700 square feet of floor area is reserved for coremaking, this department being 217½ feet long and 40 feet wide. The west end is partitioned off into a room 40 feet square, which is occupied by the women employes of the core department. Fig. 5 gives a good idea of the arrangement of the men's core department and of the kind of cores made. At the right in this photograph may be seen one of the oven cars with its notched posts for carrying adjustable shelves.

Form 333 FOUNDRY WEIGHMASTER'S REPORT

Date_____ 191__

SYMBOL	ORDER	NAME OF CASTING	PIECES	TOTAL WEIGHT	DEP'T

Sig._____

The Foundry

FIG. 18—FOUNDRY WEIGHMASTER'S REPORT OF CASTINGS DELIVERED

The cleaning room is across the shop from the core department. It is equipped with eight tumblers of various sizes arranged in a row as shown in Fig. 2. Fig. 6 also shows the tumblers and illustrates the methods employed for loading and unloading. The tumblers are gear-driven by a 10-horsepower motor. This department is also equipped with

four grinders driven through a line shaft by a 30-horsepower motor. A 40-horsepower motor operates the fan in the dust collector system. As shown in Fig. 6, each tumbling mill and grinder is connected to the dust collector system by direct piping which discharges into the dust bins, Fig. 7, situated just outside the shop. These bins have hopper bottoms with suitable valves and chutes so the dust may be drawn off into cars and conveniently carried away.

The unusual height, 22 feet, between the cupola charging doors and bottom plates permits a mezzanine floor under the charging floor. A plan of this floor is given in Fig. 2. The central portion is used for storage and for the blowing machinery, which consists of two positive pressure blowers, interconnected, each driven by an individual 30-horsepower motor. The south wing of the mezzanine floor is fitted up with shower baths, while locker space and wash basins are provided in the north wing. The ventilating fans are also placed on this floor. The northeast corner of bay No. 5 is partitioned off and is fitted up for a small brass foundry, being provided with suitable molding machines and furnaces.

A number of simple forms have been devised for checking production and keeping track of orders. Orders for castings are received by the foundry from the production department on the sheet, Fig. 15, which contains columns for checking the pieces as produced and delivered, for keeping a record of spoiled pieces and is a receipt for all quantities delivered on the order. This form is kept in the foundry office.

Upon the receipt of an order on this sheet, the foundry clerk makes out department orders, one on the card shown in Fig. 16, for the core room, one on the card, Fig. 14, for the molding room, one on the card, Fig. 15, to the cleaning room, and one on a card for the pattern storage. These forms are largely self-explanatory. The core room order is issued in advance of the others, so there will be no delay in waiting for cores. The pattern order card contains a complete record of patterns and parts of patterns delivered on a given order and when the patterns are returned they are checked against this record to be sure no pieces are lost. The cleaning room order, Fig. 15, shows the kind and number of cores in each casting and the department to which castings are to be delivered.

A record of every shipment of castings, showing order number, name of casting, number of pieces, total weight and department receiving castings, is kept by the foundry weighmaster on a sheet shown in Fig. 18. The record of pieces delivered entered on the sheet, Fig. 17, is made up from the weighmaster's reports.

Each molder is provided with a card, Fig. 19, which provides a complete record of two weeks' work, the interval between pay days. This record is kept by the instructor of the department in which the man works. The form is largely self-explanatory; a separate column, headed by the pattern number, is used for each different pattern. The pay roll is made up from these records.

The foundry superintendent keeps closely in touch with the progress of all orders in the shop, and also consults frequently with the heads of other departments and with the works manager in order to be familiar with the work which the foundry will be called upon to do. Since all production originates in the foundry, the machine shop and other departments being absolutely dependent on it for their raw material, the foundry superintendent at all times is familiar with the progress of orders throughout the entire factory.

RECORD OF MOLDS PRODUCED

Name Samuel Kezner Date April 10–24 No. 347

	PATTERN	264 D1		398 P4		216 D1														DAY WORK	
	NUMBER OF MOLDS WANTED	300		20		1700															
	WIEGHT PER MOLD	10		75		10															
	PRICE PER MOLD	2½c		10c.		2½c															
		PERFECT MOLDS	IMPERF'T MDRS	PERFECT MOLDS	IMPERF'T MDRS	PERFECT MOLDS	IMPERF'T MDRS	PERFECT MOLDS	IMPERF'T MDRS	PERFECT MOLDS	IMPERF'T MDRS	PERFECT MOLDS	IMPERF'T MDRS	PERFECT MOLDS	IMPERF'T MDRS	PERFECT MOLDS	IMPERF'T MDRS	PERFECT MOLDS	IMPERF'T MDRS	NO. OF HOURS	PRICE PER HR.
April	10	140	0																		
	11	140	10																		
	12	20	–	20	–																
	13					141															
	14					137	– 3														
	15					147	4 –														
	16	Sunday																			
	TOTAL MOLDS																				
	TOTAL VALUE																				
	DISCOUNT																				
	NET VALUE																				

The Foundry

FIG. 19—MOLDER'S DAILY RECORD OF MOLDS PRODUCED

Aluminum Solder

A new aluminum solder, recently patented, consists of a mixture of silver, phosphorus, copper, tin, lead, aluminum and zinc. The formula preferred by the inventor is as follows: Silver, 22 grains; phosphorus, 42 grains; zinc, 939 grains; lead, 1,338 grains; tin, 5.051 grains; aluminum, 50 grains, and copper, 238 grains. It is claimed that the solder possesses a low coefficient of expansion and is adapted not only for soldering aluminum, but also for other metals.

The Buffalo Forge Co., Buffalo, reports that it is filling an unusually large number of export orders for down-draft forges for installation in foreign railroad and industrial plants. Among these are the Havana Railways, Havana, Cuba, Central Railway of Brazil, etc.

OPEN-HEARTH STEEL FOUNDRY PRACTICE*

A discussion of the problems involved in the manufacture of steel castings by the basic open-hearth process

By R. A. Bull

THE manufacture of steel castings from the open-hearth furnace has been accompanied with such a remarkable progress in the last 15 years, and has reached such a commanding position in the foundry world today, that it provides a topic of very general interest, and one that should be fruitful in the matter of discussion. It is, obviously, impossible to cover the subject more than briefly in a paper such as this and I shall confine my remarks as nearly as possible to a cursory treatment of some of those questions of operation which are of particular interest to all foundries making open-hearth steel.

Melting.

It seems hardly necessary to discuss furnace construction. However, by way of introduction, it will not be amiss to explain for the benefit of founders of other metals than steel, that the two types of open-hearth furnaces—acid and basic—are of the same construction, except for the material used as a bottom. The furnace is of the regenerative type, and has a rectangular shape, with a shallow bath, the fuel being introduced intermittently from each of the two ends or ports. Natural gas, artificial gas, fuel oil, or crude oil provides the fuel, and where oil is used it is atomized by compressed air or by steam or, sometimes, by both. Where the furnaces are sufficiently distant from the boilers to condense much of the steam, it is advisable to superheat the latter before it enters the burner. The dryer the air or steam, the better will be the atomization. It is not a difficult matter to make the furnace superheat its own steam by means of a coil set into the flue, either on the furnace or the stack side of the valve. When ordinary pipe is used for this purpose, valves should be provided at the inlet and outlet of bypassing through the coils, so that the supply line containing the wet steam can be depended on, should the coil burn out.

The roof of the furnace is, of course, arched. There are many differences of opinion concerning this seemingly simple feature, and these arise from the disastrous experiences had with some forms of roof. It is a serious matter to have the roof fall into a charged furnace, and this may be due to defective construction or careless melting. Some roofs are constructed with a sort of downwardly projecting baffle near the ports, to deflect the flame to the bath. This object is attained, I fear, at the expense of cutting-out the roof and causing it to cave. Certain roofs are sprung in both directions, horizontally and transversely. I favor the straight type of roof, that is, one having the same radii, without projections from port to port. Snce the furnace is always hotter on the tapping side than on the charging side, due to loss of heat through the charging doors, causing the roof to burn out more quickly near the back wall, it has been found worth while to make the roof at this point 13 inches thick, tapering gradually to 9 inches, obtaining this graduation by special silica shapes. Of course, the radii of the inside of the roof are made identical, the difference being on the top or outside. Great care is exercised when lighting a new furnace, in properly loosening the tie rods for graduated and uniform expansion of the roof, to avoid buckling, and so ruining what may have been a perfectly constructed roof.

Construction.

As with the roof, so with the checkers and the stack is it advisable to provide more generously for the foundry than for the mill, and all for the same reason, namely, because of the higher working temperature, generally speaking. With a properly designed roof, well constructed, with ample checkers and with a high stack of suitable diameter, given careful manipulation by the melters, and the use of first grade brick throughout, a basic stationary furnace fired with oil should turn out 450 heats for the foundry without more than the usual Saturday or Sunday repairs. The acid stationary furnace should make 600 heats. The gas-fired furnace of either type will not last so long, because it is not possible to so nicely control and direct the flame as with oil. The tilting furnace, naturally, suffers displacement of its brick by rolling it in tapping and its life is very short. It has some advantages over the stationary furnace, but these are not generally regarded as balancing the disadvantages.

Use of Fuel Oil.

Insufficient attention has heretofore been given by most foundrymen to proper atomization in the oil burner. There are various patented burners on the market, but those of proper proportions for open-hearth practice are quite few in number. It is, however, only by the use of considerable skill, the acquisition of much experience, and data compiled from carefully conducted tests, that a thoroughly satisfactory burner can be produced, except by mere chance. Probably, one reason for the partial neglect of this feature hitherto has been the difficulty of metering the oil consumed. I believe it to be less than two years ago when it was impossible to secure a meter that would register closer than 12 per cent of accuracy on fuel oil. Since that time meters have been put on the market guaranteed to register within a permissibly narrow limit, and this has undoubtedly stimulated the investigation of the most economical burner. And in connection with the proper atomizing of the oil, aside from the mechanical construction of the burner, I offer it as my belief that a recording thermometer is an excellent device for the oil pipe line. Furnacemen know that fuel or crude oil will not atomize well if either too hot or too cold, and the use of a recording pressure gage on the oil line and one on the air or steam line are wise investments. By such means experiments will show what temperature and pressures give best results, the readings will show any undesirable fluctuations and the causes for these can be easily remedied. An automatic recorder to register the reversing of the burners, which should take place at approximate intervals of 20 minutes when the furnace is charged, and 30 minutes when empty, prolongs the life of the furnace.

As to the differences in construction and operation between the acid and the basic furnace, these are more easily disposed of than are the relative advan-

*Presented at the Pittsburg convention of the American Foundrymen's Association.

tages of the two practices. The acid bottom is made up of silica sand, while the basic furnace has a bottom of magnesite, or a mixture of magnesite and some basic slag. Additional sand is used for repairing acid bottoms, and magnesite or dolomite for filling up the holes that develop in the basic bottom. The acid furnace is not capable of the reduction of phosphorus and sulphur and, consequently, necessitates the use of pig iron and scrap of low content in these metalloids, for the conversion into steel of high grade. Carbon, silicon and manganese can be reduced easily in the acid furnace, and for the reason that its process is not such a refining one as the basic, its heats can be made more quickly and with less damage to the brickwork.

Basic Furnace.

The basic furnace permits the use of charges containing high phosphorus and moderately high sulphur, for these elements as well as the three reducible in the acid furnace can be worked down to permissible percentages, for first grade steel. Naturally, such refinement consumes more time and reduces the number of heats capable of being tapped without repairs to the furnace. This refining process oxidizes more metal than does the acid process, causing a higher melting loss, at the same time, charging the molten bath with more gases, which should be practically eliminated before casting. This, of course, calls for the use of proper deoxidizers, concerning the addition of which much has been learned in the past few years. Melting losses in the basic furnace average close to 9 per cent, while those in acid practice are generally claimed not to exceed 6 per cent.

Acid and Basic Castings Compared.

There is yet considerable difference of opinion as to the relative qualities of acid and basic steel castings, though not a few acid enthusiasts of yesterday are being converted into basic advocates of today. Concerning the relative economies of the two processes it is largely a question of locality and the prices of delivered suitable raw materials. But for superior castings, which must be not only practically homogeneous, but capable of withstanding severe shocks and strains, I champion the basic process, in the face of contrary opinion held by a few eminent metallurgists and sustained by many steel founders in the eastern states. I do not believe that the views held by those who decry the basic furnace because of its difficulty in producing solid castings have been formulated with sufficient knowledge of what has been accomplished by basic steel makers in the past six or seven years. It should always be borne in mind that the superior refining possibilities of the basic furnace are clearly exemplified in the product and this means much to those whose need is for steel castings containing a minimum of the objectionable elements, and whose purse will not provide for the necessarily high price charged for crucible or electrically-smelted steel castings. Our basic melters are entitled to much credit for great recent advancements in this direction and they have been ably assisted by the manufacturers of various alloys. Let no one, however, so mislead himself as to accept without question, all of the extravagant claims made for such alloys.

It is, I find, not known to all acid steel founders, familiar with basic melting or to all consumers of steel castings and metallurgists, that there are numerous steel foundries that, for several years, have made it a practice not to pour the last part of the basic heat in castings intended for purposes calling for practically homogeneous metal and steel which will successfully wthstand severe shocks and strains. There is an undesired increase of phosphorus and sulphur and a disappointing decrease in manganese and silicon in the last 3 per cent (approximately) of most heats which carry a normal thickness of basic slag in the ladle. These changes in the analyses are of sufficient degree to cause trouble if such metal be converted into castings such as were referred to previously. It is no uncommon sight to witness the pouring of this inferior metal, in steel foundries wishing to maintain a high reputation for the superiority of their product, in ingots or pigs, to be used only as are crop ends in the mill. The slag, while serving as a conserver of heat, is principally responsible for the deterioration of the metal lying just beneath it. Experiments have been made, but so far as I know, without complete success, at least in the plant with which the writer is associated, to dispense with the basic slag after tapping the furnace and to substitute for it some other covering which will prevent the chilling of the steel and at the same time not affect the elements in combination. The chief difficulty is found in mechanically removing the slag, which must be done with promptness and thoroughness in the face of decidedly awkward and physically unpleasant conditions. Notwithstanding such handicaps, the possible results are of sufficiently great importance and economic value to justify continued application of ingenious effort in this direction.

I prefer not to leave the topic of melting without briefly advocating, for humanitarian and economic reasons, three eight-hour shifts on the open-hearth platform. I firmly believe man to be incapable of his most efficient physical and mental labor prolonged for 12 hours per day, and for seven days per week, in the face of such trying conditions as are those of a furnace man, especially during the hot months of the year.

Patternmaking.

The next natural topics for discussion will be the foundry and its sisters, the core room and pattern shop. Regarding the latter there is not much to discuss which is characteristic of open-hearth steel plants, and yet of common interest to all of these. I wish by no means to give the impression by this statement that the pattern department, in my opinion, is comparatively an unimportant member of the works' organization. Its function is not to be overestimated and goes far beyond the cheapest method of constructing patterns which can be used for making castings. The strength and type of patterns are regulated by the number of castings ordered and the most economical method of producing them. And since many open-hearth plants daily make castings varying in weight from a few pounds to several tons, on orders calling for one casting to several thousand, it can be readily appreciated that the variety of work necessitating diversity of methods, gives ample opportunity for the ingenuity of the pattern foreman, whose experience must be broad enough to adapt the construction of the pattern to the job, whether the material used be white pine, maple, red wood, mahogany, gray iron, brass, aluminum, or what not, and to intelligently make the proper shrinkage and warpage allowance, greatly varied as they are in steel work.

Covering Core Pattern.

While dealing with the subject of patterns, I do not like to pass to the next one before suggesting to those whose work is of such a nature as to permit its extensive use, and who may be partially unaware of its adaptability, the enormous possibilities of the covering-core pattern. I think its value is greatest in the open-hearth foundry because of the increased difficulty there in preventing scabs and strains with large copes, in casting. Covering core is really a misnomer, but the term is used for want of a better one, and at least readily conveys its meaning to foundrymen, to whom the principle is not new. I do not believe any one, who has not seen for himself with what reduction to foundry cost this use of a copeless mold can be economically applied, can

fully realize its advantages. Naturally, its usefulness is largely confined to designs with large area and open spaces between top members of small or moderate width, all without great variation from the same horizontal plane. I have in mind a certain intricate casting which occupied a floor space over-all of about 120 square feet and weighed only 3,300 pounds. It required one nine-hour shift and five hours of the succeeding shift for eight molders and five helpers, or equivalent of about 12½ molders and 7½ helpers to make one mold with cope and drag. The use of the covering core later for this same job permitted the finishing of two molds (and by the way, much better ones), resulting in a lower piecework rate for chipping the castings) by 12 molders and six helpers in one nine-hour shift. The piecework cost for labor in making the covering cores for one mold amounted to $1.80. As the cost of core rods, core sand, baking cores, etc., is more than offset by the cost of facing, gaggers, and such materials in the cope, the proportion in favor of the covering core in this case is as two to one. Additional advantages are the elimination of crane service for handling large, unwieldy copes, and the reduction of floor space required on the molding floor.

It is, of course, generally known that silica sand of about 97 per cent purity is the material required for both mold and core, in the case of the former being mechanically mixed with such ingredients as fire clay, molasses, glutrin, water, etc., and in the case of the latter, with the previously mentioned substances and flour, oil, dry core compounds, etc. Attempts have been made to produce permanent molds for steel castings, but with very little success, and the field for usefulness here seems to be exceedingly narrow. Unobstructed by corners or angles, cast steel will shrink ⅛ inch per foot and this excessive contraction is the apparently insurmountable barrier before the ready adoption of the mold which will maintain its form in shaking-out.

Up to about 15 years ago it was not believed possible to pour steel in molds not thoroughly dried and secure castings much less porous than a sponge. The west was the pioneer in experimentation here, as in many other problems of the steel founder, and demonstrated this to be a fallacy. As a matter of fact, while a perfectly dry mold will produce a more homogeneous casting than will a green mold, the specific gravity of castings made in green sand, not skin-dried, is found by very careful experiment to be only 4.3 per cent less than that of steel castings poured in well baked molds. While it is always the desire of the customer and the ambition of the founder to secure castings of perfect homogeneity, and each knows that a well dried mold is necessary for such purpose, nevertheless there are many cases in which it is quite impossible to properly provide for natural contraction of the cooling casting without resort to green sand for mold or core. In such instances it is manifestly wise to sacrifice the 4 or 5 per cent of greater density by producing a casting free from shrinkage cracks, some of which are not always observable on the surface. For this reason the use of green sand in steel molding has its very important applications. Portable oil burners are successfully resorted to as skin dryers for molds not of convenient size and conformation for thorough oven baking.

HEAT REPORT

.....191...

To the Gen'l Supt:
Furnace No.....Tapped Heat No.....At.....M.....Test Block
Charged Extra..... ...Lbs. Poured in Molds.....Lbs.....Pigs
....Ingots. Last 1200 Lbs. Cast (Disregard if as much as 1 Pig or 2/3 Ingot is Poured):.....
Remarks:.....
.....Heat Checker.
Nature of Shut-off.....
.....Weight of Spills.....
Temperature—of Ladle.....of Metal.....
Quietness of Metal.....
Cause for Fdy. Dept's Delay to Heat.....
.....
Weight of skull .....
Remarks:.....
.....
.....Fdy. Foreman

Results of all	C	P		C	P		C	P		C	P	
Preliminary Analyses	C	P		C	P		C	P		C	P	

.....Chemist.
Condition of Furnace after Preceding Heat (Including Bottom, Roof, Ports, Etc.)..
.....
.....
Charged at.....M. by.....
Oil Pressure (Lbs., Regularity and Temperature).....
.....Steam Pressure (Lbs.).....
Air Pressure (Lbs. and when used).....
Quality of Scrap.....
Action of Furnace.....
Condition of Furnace During Heat.....
Cause for Delay to Heat.....
Cause for Addition of Extra Pig
ure when Tapped.....
Character—of Tap.....of Introduction of Final Additions.....
Remarks:.....
.....
.....Melter.

FIG. 1—HEAT REPORT FORM FILLED OUT IMMEDIATELY AFTER HEAT IS POURED

Preparation of Facing and Core Sands.

The preparation of the facing and core sands is all important and is mechanically performed by methods sufficiently well known to require no description here. The mixtures, however, deserve a few remarks. The character and amount of bonding material varies, necessarily, with the quality of the sand available and with the degree of thoroughness with which the mixing is done. It is usually found highly economical and eminently satisfactory in every way to use a large percentage of old sand in the facing and core mixtures, many foundries using 50 per cent of such old sand and some a larger amount, though I know of steel foundries where all of the old sand is consigned to the refuse cars, extravagantly, as I believe. However, the amount of old sand best to use depends somewhat on the nature of the work to be produced and the amount of fire clay, or other bonding materials necessary, varies as the percentage of old sand varies, since the latter carries clay or other bonds in greater proportion than does the ordinary silica sand as found in nature.

In large foundries an economical method of recovering and handling this black or old sand is by the use of a lifting magnet and a grab bucket. The magnet is used to wash the floor, so to speak, and take from it the spills, gates, risers, etc., after which the clam-

shell bucket follows to pick up the sand a yard or two at a time, and dump it in the storage bin.

It is well to provide very generously in the way of sufficient dry pans or other mechanical mixers, to make possible, at all times, and in spite of occasional break-downs, the thorough mixing of the facing and core sand, so that suitable strength of each can be secured with the minimum amount of bonding material.

Since molding methods are in their essentials, practically the same for all metals, we will only give attention to certain of these methods, peculiar to open-hearth steel foundries. For bottom pouring, necessary for such foundries, it can be understood by those who have never had experience with the manufacture of steel, that the mold must be rammed very hard, to avoid straining and breaking out under the pressure of the stream from a large ladle. For the same reason, the flask must be very strong and rigid and the closing of the mold attended with every precaution against run-outs. Because the mold is rammed hard, reducing to a minimum the voids between the globules of sand, ample vents must be suitably placed to permit the escape of gases in pouring, and to satisfy the high shrinkage common to steel, risers or sink-heads of sufficient number and size are provided. These risers are sometimes kept molten for feeding purposes beyond their natural freezing point by the use of stirring rods, charcoal, or thermit.

In labor saving devices for making the mold itself, the jolt-ramming machine ranks high in the open-hearth foundry, and is being made more and more flexible in its applications to diversified work and peculiar conditions. Its operation is familiar to all foundrymen, and to those in the open-hearth field it appeals strongly because of its peculiar advantages here, where hard, uniform ramming is essential.

Cores For Steel Castings.

Because of the severe pressure of the molten metal on the mold, cores of various kinds for the open-hearth steel foundry must be better reinforced with rods than those used for other metals, to avoid springing, and they must be more collapsible than those used in the gray iron foundry, because of the excessive shrinkage. For this purpose, sawdust, coke, cinders, etc., are frequently resorted to, and the dry core compounds are of great benefit, since they enable the preparation of core sand having the requisite bonding strength, at the same time making the core less refractory than does flour.

It is the customary practice to fire the core oven with coke, but careful and intelligent experimentation with an oil burner under the cores will, I think, convince many of those still using the coke fire that much speedier and somewhat more economical results are obtained by baking the cores over a fuel oil flame. Naturally, the relative economy depends to large extent on arbitrary conditions, such as the delivered price of each kind of fuel, the available storage facilities for each, and the available steam or air for atomizing. Moisture in the steam line is very easily eliminated by making the oven superheat its own steam by means of a coil of wrought iron pipe, laid on top of the arch of the fire box, through which the steam by-passes before entering the burner.

Pouring the metal into molds justly receives the closest attention. Aside from the waste and attendant unpleasantness due to leaky stoppers, which may be the result of the ladleman's' carelessness, the use of defective materials, or the melter's poor judgment, there are found at times scrap castings as a result of clean, but unskillful pouring. Preliminary to tapping the furnace, the ladle is daubed over its brick lining and dried, usually with an oil flame, for about three-quarters of an hour. Then the stopper rod is adjusted, and the lever raised and lowered to see that the nozzle correctly seats the stopper head. If the metal, on entering the ladle, is not hot enough, or if the cold additions are thrown into the ladle too soon, a skull of half-frozen metal will form around the nozzle, preventing the seating of the stopper head and thereby a clean shut-off, until such skull has been melted and freed from the nozzle. If the metal is too hot, the nozzle is frequently first to suffer by cutting-out, and this usually results in a heavy per cent of spills. Should the ladleman permit the stopper to float, or not pinch the stopper tight against the nozzle, a small dribble may appear, and by soon cutting the nozzle, result in a most serious leak. Care must always be exercised not to raise the stopper too high on the first mold, or to close it too soon, after being first opened.

Cleaning and chipping steel castings do not offer any novelties to foundry methods in other metals, other than the increased difficulty of removing the tougher metal. The use of pneumatic chipping hammers, cutting-off saws, sand blasts, tumbling barrels, and similar equipment, depends largely on the character of work in each individual shop. The welding of minor defects in open-hearth steel castings, when properly performed, is attended with good results and is permitted with reasonable limitations by most of the large consumers, such as the railroads and the United States government. Both the autogenous and the electric method have their respective adherents. My experience has been that the former is more suitable for very light sections, and the arc better for medium or heavy sections in

HEAT NO......

Final Chemical Analysis of Heat	C	P	S	Mn	Si

PHYSICAL TESTS

Elastic Limit per sq. in.....
Tensile Strength per sq. in.....
Ratio of Elasticity, %.....
Elongation in 2 in., %.....
Reduction of Area, %.....

PHYSICAL ANALYSIS OF METAL CHARGED.

.....Pig .....Lbs.=.....% Rail.....Scrap .....Lbs.=.....%
..... " ..... " .....% Spg..... " ..... " .....%
..... " ..... " .....% ..... " ..... " .....%
..... " ..... " .....% ..... " ..... " .....%
..... " ..... " .....% Fdy..... " ..... " .....%
Total pig ..... " .....% Total Scrap ..... " .....%

Approx. % of all Scrap Cstgs.....
Cracked Cstgs.....
Hollow Cstgs.....
Mis-run Cstgs.....
Remarks.....

FIG. 2—FORM FOR FINAL HEAT REPORT

cast steel. In the application of either method, ample heat must be produced for satisfactory work. Good welds cannot be expected with insufficient gas or amperes of current. Pre-heating and after-heating the castings, if of heavy or uniform section, tend to prevent the cooling strains from causing injury. Hammering the weld intermittently while under heat, checks the formation of slag and gives a closer union. On a tensile test one should get an average efficiency of 60 to 65 per cent of the ultimate strength of the natural cast steel. The elongation and reduction of area are considerably reduced. Analysis shows the metalloids to be almost entirely oxidized, leaving nearly pure iron in the weld, and thus explaining the loss in strength.

The annealing of steel castings must be very carefully done, and attended with constant reference to a reliable pyrometer, to be of the slightest value. The generally accepted correct annealing temperature is about 800 degrees Cent. Should the casting be subjected to a temperature appreciably lower or higher than this figure, more damage than benefit accrues. Hence, the necessity for extreme nicety of operation in annealing castings lacking uniformity of section, to avoid over-heating the lighter members and under-heating the heavier ones. The necessity for annealing at all should be governed largely by the composition of the steel, whose analysis may be such as to make of annealing a needless operation for ordinary work.

The loss in bad castings, of course, depends to no small degree on the severity of the inspection, and the class of work common to the shop. However, the ordinary open-hearth steel foundry, producing an average run of work and following a thorough and intelligent inspection system will, if my observations count for anything, have close to 4 per cent of scrap castings, if working molders and coremakers during daylight hours only, and 6 per cent if compelled to employ this labor on both day and night shifts. The cause for this difference is readily understood by any foundryman.

The writer has found that a follow-up report system of each individual heat is very helpful, and in Figs. 1 and 2 forms are shown used for this purpose. It will be seen that some days must elapse before all of the information called for can be supplied. The plan is for the report to reach the operating head usually inside of an hour after the ladle has dumped the slag, with all data supplied by heat checker, foundry foreman, chemist and melter on the title side of the sheet, which is then filed in a convenient fashion in the operating office. From then on the acquisition of the remaining data is gradual as the work progresses through the plant, being transferred to the reverse side of the sheet as the various reports are transmitted. I have found that such a condensed general history of each heat poured is a most helpful auxiliary to the numerous reports in greater detail.

"Furnace Stoker Proofs" is the title of an eight-page folder, issued by the American Stoker Co., 11 Broadway, New York City, which contains a partial list of the stoker installations made by this concern. The repeat orders are numerous and contain a large number from some of the leading foundries.

German Radiator Molding Machines

By Dr. Alfred Gradenwitz

THE increasing use of steam and hot water heating systems in Germany, with their consequent demand for radiators, has made it necessary to adopt machine methods of molding in foundries making a specialty of these castings. For molding radiators, a machine developed by the Vereinigte Schmirgel und Maschinenfabriken, Ltd., Hannover-Hainholtz, Germany, presents many points of interest. On this machine from 100 to 120 radiator molds can be made in a ten-hour day by a crew of three men, using a hand-operated machine.

The machine, Fig. 2, consists of a substantial cast iron frame, in which the machine body is free to rotate. The movable portion consists of a rectangular frame, which revolves on pivots attached to the center of each of the long sides, *A*. The inner sides of the ends of this frame are fitted with V-shaped projections paralleling each other and extending the entire length of either side, *A*, Fig. 1. Between these two lateral guides the working parts of the machine slide up and down. The ramming pressure is applied by the crank shafts, *BB*, Fig. 2, which are operated by two gears keyed to their ends. These gears are enclosed in the wide, hollow section of the frame adjacent to the operating end of the machine. The crank shaft gears are actuated by a hand wheel, through a train of gears. The power applied to the crank shafts is transmitted to the parts, *CC*, Fig. 2, which are moved vertically in the V-shaped guides on the inner sides of the frame ends. The sand in the flasks is

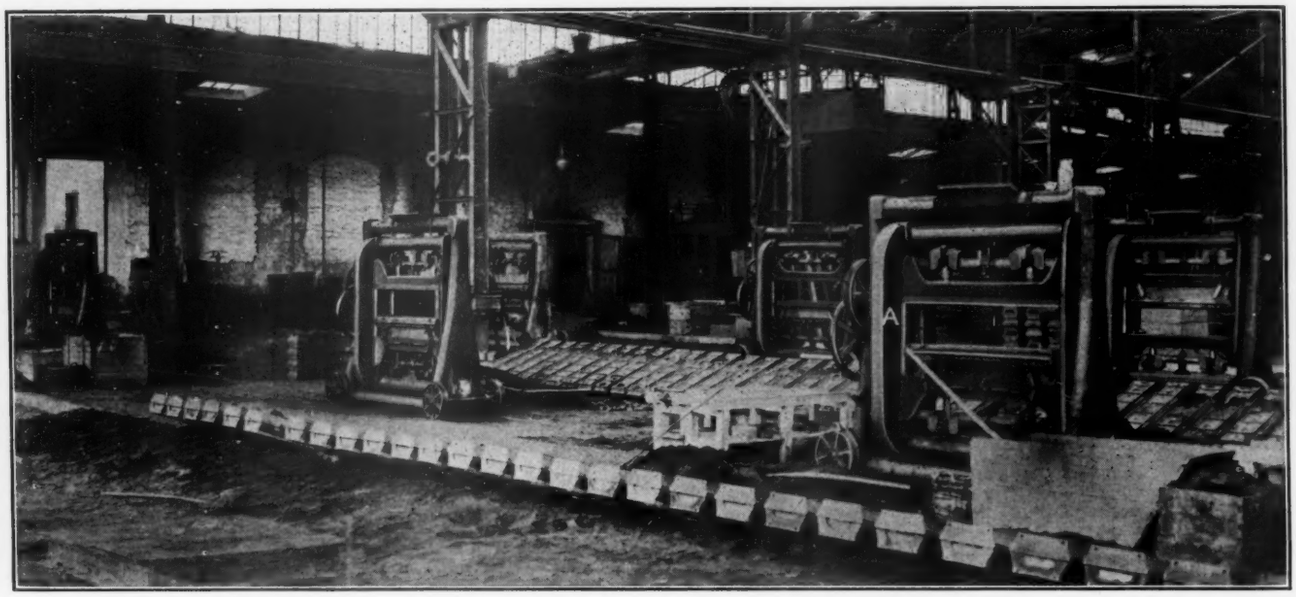


FIG. 1—VIEW OF A GERMAN RADIATOR FOUNDRY

rammed by the movement of the upper and lower presser heads, and the cope and drag are raised and lowered away from each other by the continued operation of the hand wheel.

No bottom plates are required on the flasks, and instead of the usual frame each half is a rectangular box, with the bottom cast on, which forms a part of the flask. The bottom is pierced with numerous holes for venting, and is provided with a suitable opening at one end for the sprue. The patterns are, therefore, pressed into the sand, instead of the sand being rammed onto the patterns, the latter being mounted on one of the movable parts, *C*, while the other gives the counter pressure. When operating the machine, the rotating body is locked in its vertical position, and sand is filled into a retaining frame, at the bottom of which are the patterns, the machine being inverted from the position, shown in Fig. 2. A flask is then placed on tables, *D*, and as the hand wheel is rotated, the patterns are pushed up inside of the filling frame, compressing the sand in the flask. The machine body is then rotated to the position shown in Fig. 2, and the drawing of the patterns is effected by the continued rotation of the hand wheel, which leaves the mold in the position shown, ready for the core.

Fig. 1 is a view of a German radiator foundry, operated by the Vereinigte Schmirgel und Maschinenfabriken, Ltd. In the foreground is a floor of radiators and the arrangement of the radiator molding machines is also illustrated.

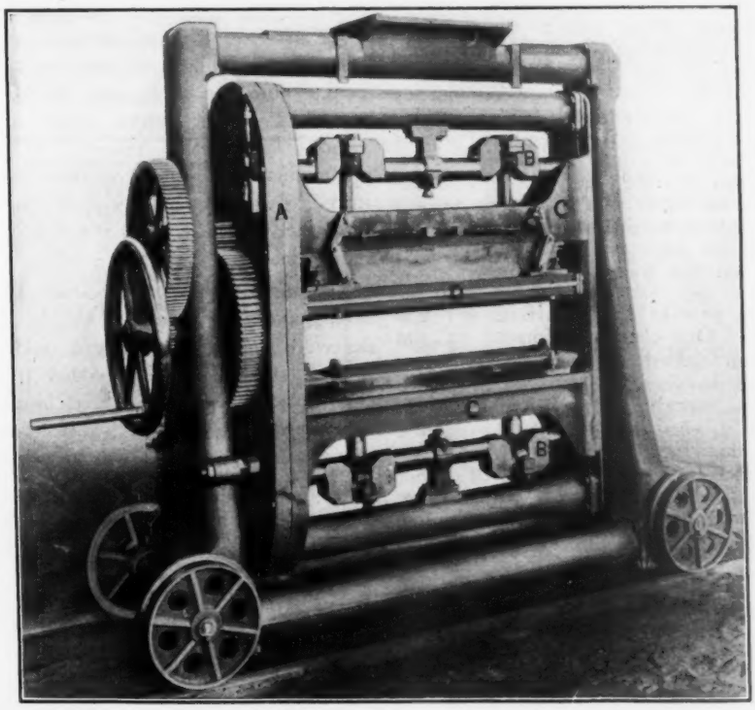


FIG. 2—GERMAN RADIATOR MOLDING MACHINE

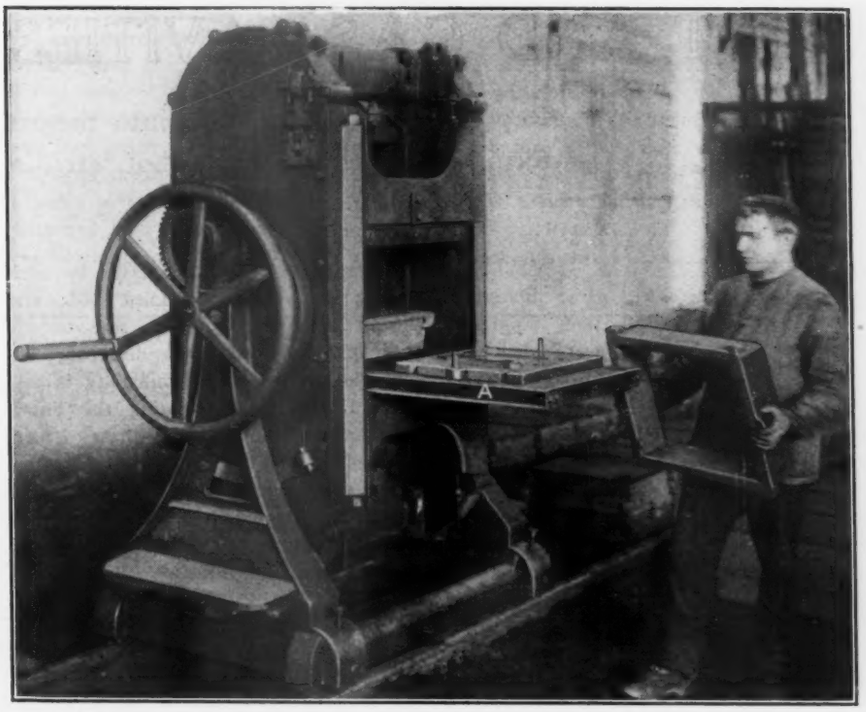


FIG. 3—GERMAN SPLIT PATTERN, POWER-SQUEEZING MOLDING MACHINE

A machine of similar design, manufactured by the same concern, but adapted for other work, is shown in Fig. 3. The operation of the machine is substantially the same as the one described in that the squeezing of the sand, the rolling-over of the mold and the drawing of the pattern is accomplished automatically by the continued rotation of the hand wheel. This machine is adapted for split pattern work. The pattern plate, *A*, Fig. 3, is drawn forward in the position shown when the flask is to be set in position. The flask is then filled with sand and with the pattern plate, is pushed back under the presser head. When the hand wheel is revolved, the presser plates compress the sand in the flask. When the two crank shafts have reached their maximum movement, the rotating section of the machine is automatically released and revolving, inverts the flasks to permit of the removal of the patterns. The movement of the hand wheel is continued and the pattern is withdrawn from the mold. This machine mechanically compresses the sand, automatically rolls-over the molds and draws the patterns. All of these movements are accomplished by the hand wheel.

The May number of *American Vanadium Facts*, published by the Vanadium Sales Co. of America, Pittsburg, contains a reprint of the article, entitled "Vanadium in Cast Iron," presented by Geo. L. Norris at the annual convention of the American Foundrymen's Association held in Pittsburg. Other articles included in this number are "Vanadium Steel Castings," "Vanadium in Bearing Metals," "An Interesting Chrome Vanadium Steel Chip," and "Economy in Drill Steel." In this number are also included descriptions of the vanadium iron and steel castings exhibited at Pittsburg.

SHOT AND GAS CAVITIES IN CASTINGS*

Report of an investigation into the causes of the formation of chilled iron, shot, etc., in gray iron

By Thomas D. West

IN MAKING this investigation, samples were solicited of iron castings containing globules in gas cavities, hard streaks or spots, shot iron solidly encased or white iron intermixed with gray iron. In addition to the samples the following information was requested:

First—The character of the pig iron, scrap, fuel or flux used; also if anything unusual occurred or was observed during the heat, a description of the kind of iron produced, whether soft, medium or hard, and an analysis if possible of both the casting and the defective parts, whether shot or white iron.

Second—A sketch of the casting, showing as far as possible the thickness of the different sections with the locations indicated, of the defects of which samples were forwarded.

Third—A description of the method of molding, whether in dry sand, green sand, skin-dried molds or loam, with information regarding the method of gating and pouring the mold.

Fourth—Whether the metal was hot, medium or dull at the time of being tapped and poured, and any other information that might be of value in this investigation.

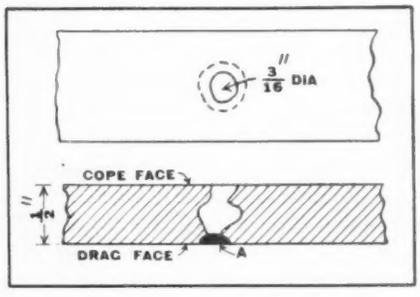


FIG. 1—PLAN AND SECTIONAL VIEWS OF A CASTING CONTAINING SHOT IN THE DRAG FACE AND BLOW-HOLE EXTENDING THROUGH THE CASTING

Losses are frequently caused by such defects as shot, blow-holes, etc., and the greatest annoyance is due to the fact that they suddenly disappear before the source of the difficulty is discovered, thereby eliminating the possibility of guarding against these defects in the future. On this point an interesting communication was received, from which the following is taken:

We note that you desire samples and suggestions regarding the formation of shot in cast iron and believe that, perhaps, some of our experiences will be of interest. From time to time we have had trouble from shot formations in our castings and as much of the work was finished, the tools were quickly dulled by the shot and frequently had to be reground. We have tried almost everything we could think of to prevent this trouble and when it disappeared we never could trace it to any remedy that we had applied. We conceived the idea of making iron shot based on the theory that if we could produce this shot we would also be able to prevent the recurrence of this trouble. Our chemist informed us that the iron spilled in the foundry when charged in the cupola, trickled down through the charge and being insufficiently melted it was mixed with the molten metal, thus forming shot in the castings. We, therefore, placed some of these chilled particles in a ladle with molten iron and poured a number of molds, but were unable to find any shot in the castings. We also tried hard rattling stars, small set screws and pieces of steel, both in the ladle and in the mold, on top of which the iron was poured, but no shot was produced. We then tried wetting the gate of a mold to make it blow, but without result, insofar as shot is concerned. While the damp hard sand caused blow-holes, it did not produce shot, and while we carried out every suggestion that might lead to the formation of shot, we were unable to produce it, even under the most favorable conditions. We, therefore, reached the conclusion that shot was formed by something in the iron mixture and on that basis we will endeavor to effect a cure.

Other letters received related similar experiences. One foundryman was under the impression that the hard iron stars used for cleaning the castings became mixed with the sprues and scrap and it was believed that this was the cause of the shot in the castings. However, after care was exercised to prevent the possibility of the stars from getting into the scrap, the trouble still continued. The general trend of the various experiences reported in these communications would indicate that the introduction of small chilled particles into the cupola is not responsible for the formation of shot.

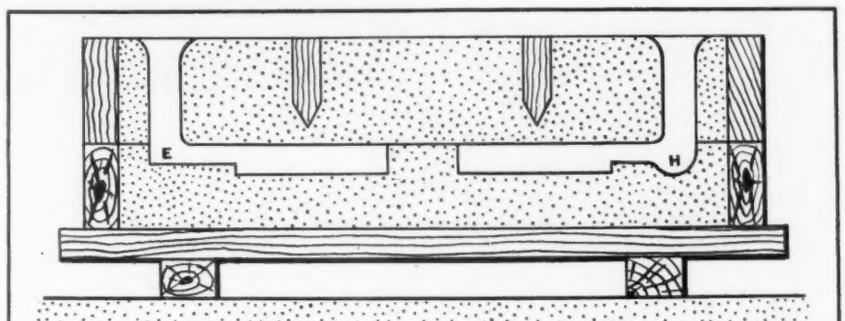


FIG. 2—SECTION OF MOLD, SHOWING THE PROPER METHOD OF GATING AT *H*, AND THE IMPROPER METHOD AT *E*

The firm whose letter has already been quoted, forwarded a sample of the defective casting containing a small button or shot, loosely embedded in that side of the casting that had been cast downward. The sample showed a crease made by the tool as it was sprung when coming in contact with the hard spot, and also the chisel indentations caused by removing the button from the planed surface of the casting. This sample was exceedingly interesting and a peculiar feature was a small, vertical blow-hole which extended through the casting from the top of the shot to the cope surface and when the shot was removed there was an opening through the casting about ½ inch in thickness. In Fig. 1

*Presented at the Pittsburg convention of the American Foundrymen's Association.

is shown a cross-section through the defective part of the casting, showing the blow-hole and the location of the shot. It is evident, therefore, that as the shot was formed on the lower surface of the casting, gas was generated which escaped through the cope, but not sufficiently fast to prevent the formation of the blow-hole. It is unfortunate that this sample of hard shot is too small to afford sufficient material for a complete analysis, which would materially aid in the solution of the problem.

White Iron Cemented in Gray Iron.

Several samples of soft iron castings were received containing small bodies of strictly white iron, solidly enclosed or cemented therein. The term *cemented* is used because the spots or white bodies are not loose in the casting and are as solidly united as it is possible to unite two different bodies. This defect not only occurs in the form of shot, but also in the form of streaks of considerable size, and is found most generally on the surface of the castings uppermost in the mold. Some shot iron was received that had been taken from the cupola spout after the bottom had been dropped. It was the opinion of the party who sent these samples that they were the cause of blow-holes. This shot was tested by placing it on the bottom of an open sand mold, the casting being about 3/8 inch in thickness. While casting, no disturbance of the metal such as would be produced by the escape of gas, was noted, and when the casting was broken it was found to be perfectly solid at the point where the shot had been placed. Tests were also made by placing the shot on the bottom of closed molds, the casting having

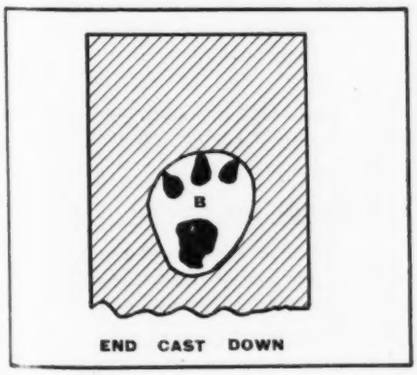


FIG. 3—SECTION OF A MOLD CONTAINING A GAS CAVITY WITH GLOBULES OF IRON AT *B*

been poured with hot and with dull iron. In the casting poured with the dull iron a small gas cavity or blow-hole was found directly above the top of the shot. The foundryman who sent this sample of shot stated that no blow-holes were formed in the castings poured from the first part of the heat, which consisted largely of pig iron, but that blow-holes developed toward the end of the heat when the charges were composed largely of scrap. The shot was sufficiently soft to permit it to be slightly flattened in a vise before it cracked. These experiments proved, that aside from the question of blow-holes, cold shot iron, when placed in a thin casting of from 1/8 to 3/8 inch in thickness, is not melted, but is merely enveloped by the metal, and when the casting is broken the shot is found intact. When shot is formed while pouring a casting, the metal in a section under 3/8 inch in thickness will have no melting effect on these small particles if they become chilled below a red heat and, in fact, the shot so formed will have to be near the fusing point to be melted.

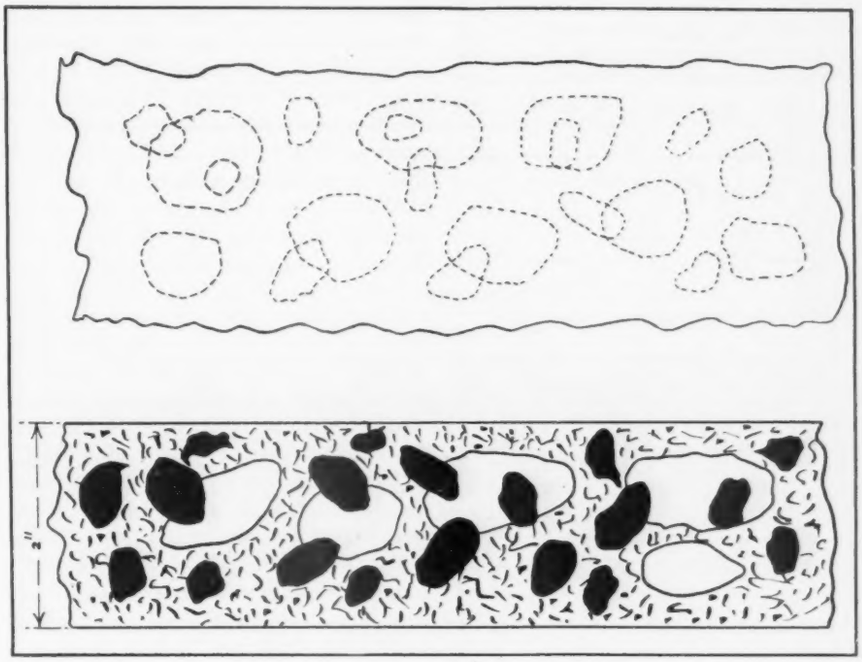


FIG. 4—PLAN AND SECTIONAL VIEW OF CASTING CONTAINING NUMEROUS CAVITIES AND LARGE BUTTONS OF METAL MIXED WITH THE IRON AND DROSS

Causes of Shot Formation.

A logical theory of the formation of shot in castings is that these small particles are produced by their sudden separation from the general mass of metal during the pouring of a mold and being small, solidify so quickly that the carbon has not sufficient time to assume the graphitic form. The shot is, therefore, hard instead of soft, as would be the case if the time of cooling were extended over the period required for the solidification of the casting. The greater the distance the shot travels before it lodges and the cooler the air through which it passes, the harder it will be. The hardness is also affected by the degree of dampness of the spot upon which the shot may lodge. Where shot is caught and covered by incoming metal before it has time to cool below a red heat, the chances of its being hard are less than when it has had time to cool beyond this point. Particles of shot are formed by the metal striking the sides of a pouring gate or basin and also by falling upon a flat bottom inlet gate, as shown at *E*, Fig. 2. Furthermore, shot may be formed by the metal spattering when it strikes some obstruction in entering the mold.

Flat Bottom Gate.

In ordinary practice there is probably nothing that will cause more spattering and, consequently, the formation of shot than the flat bottom gate. The bottoms of all pouring gates should be dished, as shown at *H*, Fig. 2, and when so constructed there should be little hesitation when pouring is commenced. The first drops of metal fall into the well at the bottom of the gate, where they are retained in liquid form instead of being spattered into shot. When pouring the majority of molds, particularly stove plate, after the stream of metal has once been started its flow should not be stopped, even momentarily, but from the moment the metal strikes the bottom of the gate, a steady and unbroken stream should be maintained, so as to rapidly fill the gate and to keep it full until the mold is filled. This applies to flat top pouring gates gener-

ally used on stove plate molds and other similar work, as well as gates of a joint character, shown in Fig. 2. When these suggestions are followed many of the difficulties experienced from shot iron and hard spots in castings will disappear.

Using water too freely on the joint of the mold, either before or after drawing the pattern, can easily be productive of hard spots by its chilling effect on the iron and a similar effect can be produced by sand that is too wet, hard rammed molds or insufficient venting. These damp sections of the mold

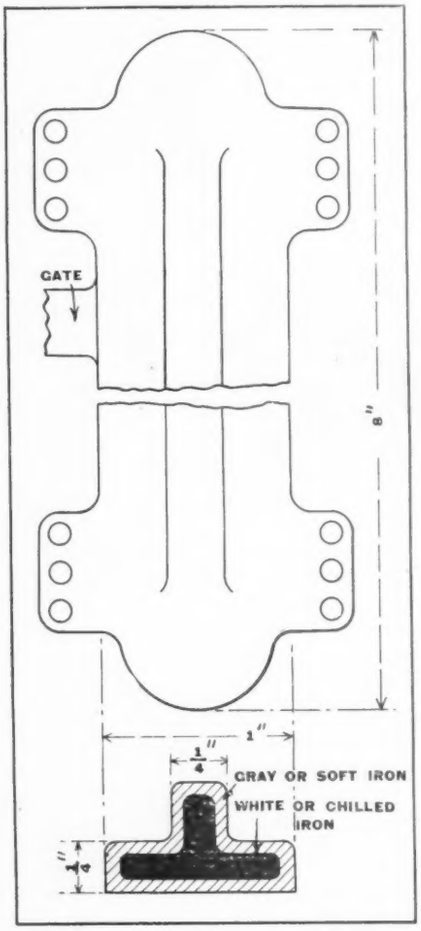


FIG. 5—PLAN AND SECTIONAL VIEW OF CASTING, SHOWING WHITE OR CHILLED IRON INSIDE OF GRAY OR SOFT IRON

are also responsible for the formation of chilled shot, as they cause bubbling and spattering of the iron to a greater or lesser degree. These small particles of iron are chilled and are carried unmelted by the iron to other parts of the mold, producing the white iron or chilled shot so frequently found in castings. While excessive dampness of the sand may not be accountable for all cases of white iron, chilled spots, streaks, etc., found in castings, it is a fruitful source of such troubles, which can be produced at will by the unskillful use of the swab, by damp sand and hard or insufficiently vented molds. Therefore, many difficulties of this kind can easily be remedied by the skilled and experienced foundryman.

Iron Globules in Gas Cavities.

The cause of globules of iron in gas cavities or blow-holes, as illustrated in Fig. 3, was the next defect investigated. This emanates from the creation of excessive gas or steam which is imprisoned within a body of solidifying metal and is generally found in the upper parts of castings. Excessive gas, which causes blow-holes, may either arise from the metal itself or may be due to defective molding or pouring methods. The formation of gas in the metal is caused by the reaction of the oxides of manganese or iron on the carbon in the iron, thus producing carbon monoxide gas, or by liberated graphite, forming kish or indirectly from sulphur by the formation of sulphide of manganese. Gas will also be generated by the combination of oxide and dross and the latter may contain some kish with the dirt from the clay of the cupola, tap hole and spout. This combination of dross and kish forms a slag which floats on top of the ladle and may find its way into the mold as a result of defective skimming, thereby causing the formation of blow-holes, pinholes and dirt in castings. These defects are also largely due to unskillful methods of molding and the improper handling of the metal.

The use of molding machines materially aids in preventing some of the defects already considered. Their method of operation conforms to the best practice ascertained by experiments made to determine just what conditions are essential to obtain the best results. The operation of molding machines is also less liable to variation than hand-molding which reduces the liability of steam and gas cavities and blow-holes which have their origin in defective molding. These machines, however, do not remove the liability to all of the defects mentioned, nor do they supersede the experienced foundryman.

Cause of Gas Cavities.

Iron globules suspended from the roof of a cavity, as shown at *B*, Fig. 3, are caused by some defect in the method of ramming, gating or pouring the mold. The gases causing these cavities may originate during the filling of the mold or not until some time after the mold has been poured and before the metal has solidified. These gases form a cavity in the metal through the top of which small drops of still partially liquid metal may ooze and thus form the shot or suspended globules, as shown in Fig. 3. Cavities created by gas from the metal or by oxidized splashes of metal should present an unbroken, bright and smooth surface, as the condition that causes the cavities continues to evolve a sufficient pressure of gas in the cavity to prevent the formation of globules. Cavities, therefore, caused by gas evolved from the metal, or by splashes, contain no confined shot, the production of which is enhanced by a lack of pressure, such as would exist when gases are merely imprisoned and cannot increase in volume. Gas cavities may be caused in castings either by the mold or the metal, or both. The mold may cause sufficient bubbling or boiling of the molten metal to cause it to throw off small particles of metal which fall back into the metal in an oxidized condition and the film of oxide on these particles evolves gas which

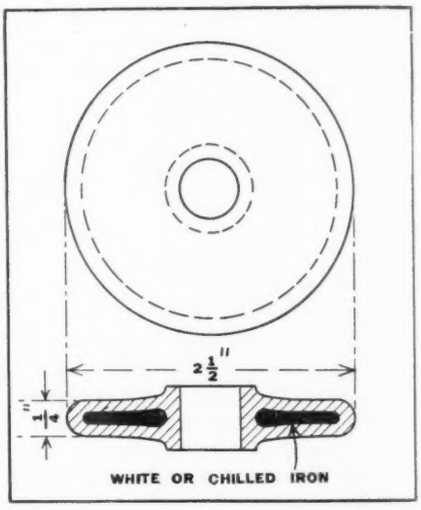


FIG. 6—PLAN AND SECTIONAL VIEW OF ANOTHER CASTING, SHOWING WHITE OR CHILLED IRON INSIDE OF GRAY OR SOFT IRON

forms blow-holes in addition to those created by the steam which produced the boiling of the metal.

Phosphorus and Sulphur Theory.

It is possible that sulphur or phosphorus may cause the formation of blow-holes, but the author has little faith in this theory, as he cannot recall seeing a blow-hole or gas cavity in a strictly gray iron casting that resulted from any cause other than defective molding. Invariably, defects caused by blow-holes have been overcome when the necessary changes in the methods of molding were made. In the cases of mixtures of hard or chilling irons, the author is prepared to seriously consider the sulphur and phosphorus theory as the cause of blow-holes in cast-

ings, but as to the cause of these defects in soft gray iron castings, he will maintain the position outlined until it has been proven that he is in error.

Experience of an English Foundryman.

A letter received from P. Munnoch, a member of the British Foundrymen's Association, contains some excellent information on the subject of chilled shot in castings, of which the following is taken:

The chief peculiarity noted in connection with chilled shot is that it usally occurs in the upper portion or near the upper surface of a casting. Generally, the shot is small in size and almost round, and in some cases partially and in others entirely fills the cavity in which it is formed. When broken, the fracture varies from gray to white, the latter being extremely hard. In Table I are given the analyses of shot and buttons and in Table II are given the analyses of the castings from which these particles were taken, arranged according to their phosphorus content. Several of these analyses were given in a paper presented by the writer before the British Foundrymen's Association, in 1908. Most of the analyses are from specimens obtained from large castings. My first experience was with gray shot, enclosed in small castings, which, on account of their size, yielded only sufficient material for partial analysis and, therefore, were very little different from the casting from which they were obtained. In some cases this shot originated from splashes of metal in the mold produced while pouring. Some large buttons, later obtained, were not caused by splashes, but must have liquated from the casting after the greater part of the metal had solidified. The analyses of these buttons were similar to those obtained from phosphoric pig iron. After the metal had solidified it was subjected to hydraulic pressure and when the results of early experiments were submitted to J. E. Stead, he expressed the opinion that the blow-holes were first formed and later became filled with a highly phosphoric liquate. Examinations of castings received from various sources showed that all suffered from this defect to a more or less extent.

Shot in Cylinder Heads.

Some large cylinder heads for blowing engines furnished many interesting specimens, some several ounces in weight having been obtained. In some cases buttons of different composition were obtained from different parts of the same casting and pieces of different compositions were obtained from the same cavity. The castings from which the specimens were obtained weighed about 10 tons. These castings varied in thickness considerably and the molds were built-up largely of cores, some of which were difficult to vent. The castings were square with a circular web and flange extending around the top and the holes were formed in the top flange and were only revealed after a considerable thickness of metal had been machined off. The holes were large and their surfaces were smooth and bright, while in one or two cases oxide and oxide struts were found. The upper surfaces were also smooth with rounded projecting crystals, indicating the rising of gases after a considerable thickness of metal had set at the top of the mold. The lower parts of the cavities indicated shrinkage in places, but the bottoms were usually covered with the liquated masses.

Characteristics of Shot Iron.

The buttons were smooth and had a bright, mirror-like surface which was retained after several years' exposure to the acid fumes of a laboratory and were also rounded on the edges and could not have been very fluid when run. In some cases small shot was partly enclosed by large masses and this, together with the difference in composition, showed that the liquated metal had not all entered the cavity at the same time, but during different periods of solidification. Occasionally, the small shot appeared to have been squeezed into the cavity. The fracture of the gray shot was similar to that of the casting and the fracture of the mottled shot was not unlike the fracture of ordinary mottled iron, while the white shot was similar to white iron with the exception that the outside showed a crystalline appearance in the form of long crystals interlaced and partly covered, in some cases, with a thin layer of graphite. There was, evidently, a contraction of the outer shell or expansion in the interior of the casting set up after the metal was almost solidified and this pressure caused the still liquid portion to be squeezed out from between the interstices of the crystals already formed, into the blow-hole cavity. The analyses of the liquid squeezed out of the low phosphorus forge pig iron are given in Table III.

High Phosphorus Shot.

In this case the exterior is solid and the still liquid metal of the interior is forced out, either by contraction or expansion. With castings this is not the case, but the phosphorus enriched liquid remaining in the spaces between the crystals is forced out when subjected to pressure. The liquid is gradually enriched in phosphorus until the phosphide eutectic containing 6.7 per cent phosphorus, 2 per cent carbon and 91.3 per cent iron, is reached and the amount of phosphorus in these buttons is an indication of the period at which they were formed during solidification. The shot that is similar in phosphorus content to the casting was probably caused by the splashes of the metal and by squeezing out the still liquid metal into previously formed cavities during the solidification of the casting. In the case of high phosphorus shot, the liquid enters the hole after the casting has practically assumed the solid state. The interior of a casting, which is the last portion to become solid, has not been found to contain more phosphorus than the outside of the casting, in fact, when spongy parts occur, the reverse condition sometimes prevails and the phosphorus enriched liquid between the crystals, to some extent, drains into the spongy portion.

Generally, the formation of blow-holes and shot are noted particularly in iron that has been oxidized in melting, instances of which can be noted when the first metal from the cupola runs cold, particularly when soft iron is being melted. If this is caught in a ladle and allowed to solidify, it often presents the appearance of a spongy mass full of shot, the holes and shot being coated with oxide and graphite. If some of this metal is left in the bottom of the ladle and hot fluid iron is poured over it, a boiling action follows

Table II.

Analyses of Castings From Which the Shot in Table I Were Taken.

	A.	B.	C.	D.	E.	F.
Graphitic carbon, per cent.....	2.74	2.80	2.90	3.25	2.80	2.85
Combined carbon, per cent.....	0.62	0.50	0.40	0.05	0.60	0.60
Silicon, per cent	1.63	1.72	1.70	1.77	1.95	1.65
Manganese, per cent.....	0.51	0.49	0.45	0.44	0.48	0.49
Phosphorus, per cent.....	0.88	0.83	0.89	1.23	0.95	0.84
Sulphur, per cent.....	0.091	0.118	0.114	0.107	0.105	0.119

With the exception of E, which was a pedestal, all the analyses in Table II were made from samples taken from cylinder heads.

Table III.

Analyses of Forge Iron and Portion Liquated Therefrom Under Pressure.

	Pig iron.	Liquate.
Graphitic carbon, per cent.	3.06	3.30
Combined carbon, per cent.	0.78	0.58
Silicon, per cent.....	1.23	1.30
Manganese, per cent.....	0.78	0.82
Phosphorus, per cent.....	0.043	0.046
Sulphur, per cent.....	0.091	0.034

Table I.

Analyses of Shot Iron and Buttons.

Graphitic carbon, per cent.	nil	0.33	1.16	nil	nil	1.68	2.02	2.44	nil	2.45
—Fracture—	White.	White.	Mottled.	Mottled.	Mottled.	Mottled.	Mottled.	Not given.	Not given.	Gray.
Combined carbon, per cent.	2.20	2.00	1.25	1.00	....	1.05	0.75	0.76	....	0.85
Silicon, per cent.....	0.70	0.84	0.93	0.60	0.86	0.93	0.98	1.26	1.14	1.32
Manganese, per cent.....	0.63	0.59	0.48	0.63	....	0.36	0.50	0.45	....	0.43
Phosphorus, per cent.....	5.68	5.45	4.88	4.84	4.64	3.80	3.20	1.92	1.80	1.70
Sulphur, per cent.....	...	0.06	0.31	....	....	0.021	0.037	0.046	....	0.021
Casting taken from	B	B	B	D	E	C	F	F	E	A

and if poured into the molds the castings produced will contain numerous holes of the shot-hole type. Holes of this kind may be either bright or tinted inside and usually contain graphite and particles of oxide in their lower portions.

At blast furnace plants when casting low phosphorus iron into pigs, after the metal appears to have solidified on the outside, the portion in the center that is still liquid, squirts out and forms small mounds near the sow end of the pig. This is no doubt due to the compression of the liquid in the interior by the contraction of the outer solidifying portion. This phenomenon is only seen in connection with the casting of the forge variety of pig iron. Holes in the upper part of this grade of iron frequently contain shot and in low phosphorus pig this is usually similar in analysis to the pig iron itself.

Comments of Mr. West.

In commenting on the valuable researches of Mr. Munnoch, attention should be directed to the fact that castings from which the specimens were obtained were of variable thickness and weighed about 10 tons and that the molds were largely built-up of cores and were difficult to vent. In view of these facts it is the opinion of the author that these buttons, shot and gas cavities were caused by the molds and that the metal had practically nothing to do with their creation. To be more explicit, if the molds in which these castings were made had been poured with metal at the proper temperature, through well-constructed skim gates, without a hesitation in the pouring as the mold filled, and if suitable provision had been made for feeding the casting, I venture to say that not a single gas cavity or button of metal would have been found in any of these castings. Mr. Munnoch obtained some very large specimens of shot or buttons which could have easily been created by the bubbling of the metal in the mold. To demonstrate this it is only necessary to watch the action of a blowing mold. The metal will be splashed in the air 3 or 4 feet, if the risers and feeding heads are blown, or if the mold is left open the metal will boil under the influence of the explosion of the imprisoned steam and gases. As the metal falls back, it can readily be conceived how very large globules or buttons could be formed by small bodies of metal lodging on flat planes, projecting bodies, flanges, etc. These buttons, having become oxidized or covered with dross, would, naturally, create gas cavities in the liquid metal with which they are surrounded.

A study of these gas cavities shows them to be of two kinds, namely, those made by the gas created by an embedded button or shot and those due entirely to gases and steam created by the mold or its cores and which form cavities, into which particles of the surrounding metal have been forced in the form of shot. A perplexing feature is Mr. Munnoch's discovery of the difference in the chemical contents of two buttons found in the same cavity and this, no doubt, will invite further study of this subject along these lines.

Shot Caused by Improper Gate.

One letter received from a concern in California stated that a large retort casting had been rejected because it contained numerous cavities and large buttons of metal mixed with masses of dross in the cope side of the casting. A section of a sample of this casting containing these defects is shown in Fig. 4. After an investigation the conclusion was reached that the trouble was due entirely to the method of gating, which permitted the metal to rush into the green sand mold and impinge on a wall of sand, which, until the depth of the metal in the mold had reached the level of the gate, and thereby retarded its cutting action, scattered the iron in all directions in the form of shot. This was mixed with dross and dirt cut away from the mold and was carried out on the rising surface of the metal and was ultimately deposited in some horizontal plane of the casting.

Iron Shot and Light Work.

The statement, that, as a rule, the molds are more responsible for the creation of blow-holes than the iron, etc., is not to be taken as conveying the opinion that no trouble is to be feared from the gases evolved by the metal, it is the author's contention that this is a feature for which the management is largely responsible, and can be guarded against to a large extent, as well as the evils arising from defective molding. A metal that is dangerously loaded with oxide of iron is readily discerned by the experienced foundryman. Light work, as a rule, suffers more from oxidizing conditions of melting than heavy work and foundrymen who handle light castings experience considerable trouble from hard spots, streaks and pin holes in their castings, due to this cause. The action of oxides in iron is similar to that of excessive sulphur, as it reduces the fluidity and causes the metal to become sluggish. Melting iron dull oxidizes it to a greater extent than melting it hot, as the higher temperature causes the metal to drop more quickly through the fuel from the point at which it melts to the bath on the hearth. Manganese and silicon by reason of their greater fluidity, aid, in the removal of oxygen and in the formation of a protecting layer of fluid slag.

For oxidizing and purifying iron a number of alloys are now manufactured which can be obtained in a ferro form and are best charged by placing them in the bottom of the ladle on top of which the metal is tapped. The quantity of this alloy to be used will depend on the character of the pig iron and scrap melted. Ferro-manganese, ferro-silicon and ferro-phosphorus containing, respectively, 80 per cent, 50 per cent and 20 per cent of manganese, silicon and phosphorus may be used in proportions of from ¼ to 1 per cent in the ladle. Phosphorus acts as a scavenger by reason of its effect in increasing the fluidity of the iron, thereby permitting the escape of sulphur and occluded gases.

The occurrence of the inside chill or white iron inside of gray iron or soft iron, must be classed among the strange phenomena involved in the founding of metals and which, to the author's knowledge, has never been satisfactorily explained. While this phenomenon is of comparatively rare occurrence, it is of importance that a solution of the difficulty be found and, as an aid to this end, the author solicits the experiences and views of others on this subject, as well as on other points treated in this paper.

Graphite Flakes in Castings

By N. W. Shed

From a southern foundry was recently received a gray iron sample, the fracture of which had a flaky appearance that was due to separated graphite. Many irons, particularly those made in the south, and containing a high percentage of silicon, are liable to deposit free graphite when they cool. This is similar to the formation of kish by the molten iron from the blast furnace. With this free graphite was found a large amount of sand in this sample, which had been taken from the runner or mold. By using a mixture containing a lower content of silicon or by using a small amount of scrap steel, the tendency of the iron to form graphite when cooling would be reduced by lowering the amount of total carbon. Rapidly cooling the metal will cause a greater amount of combined carbon and this would lessen the amount of graphite flakes formed. This flaky appearance is more common in castings made from direct metal or all pig mixtures. Remelted pig iron, with 30 to 50 per cent of scrap, rarely shows this structure. The lower silicon and high sulphur from the scrap mixture usually prevents the formation of much free carbon in the form of graphite.

THE BRASS FOUNDRY

Casting Bronze Stock Bars

MANY small machine parts such as nuts, washers and other small castings, are made more economically by turning them out of a solid bar, than when cast and finished individually, and for this purpose cast bars of copper or bronze are frequently used. In the smaller sizes, these bars present no molding difficulties, but when the diameter is over 3 inches, considerable trouble may be experienced if the castings are not properly gated. The difficulty that presents itself is caused by shrinkage, and is due to insufficient feeding, which allows the middle of the bar in the cope to sink, presenting the appearance shown by the dotted line in *A*, Fig. 3. When the diameter of the bar is 4 inches or over, the trouble is very persistent and can only be overcome by making the sprue, or feeder, equal, or a little larger in diameter than the intended casting. The sprue thus

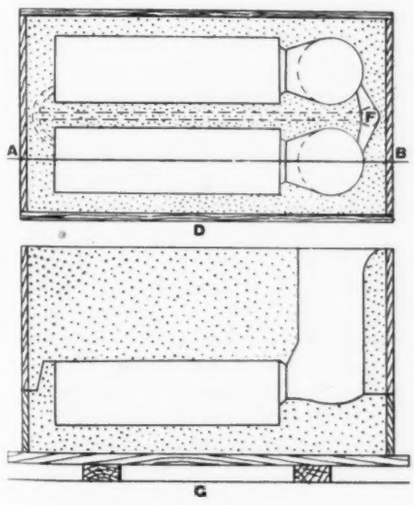


FIG. 1—PLAN VIEW OF DRAG AND LONGITUDINAL SECTION OF A MOLD FOR TWO SOLID BARS

appears to be of enormous size in proportion to the casting, but it may be stated that the same size sprue that is necessary on a casting 14 inches long by 4 inches in diameter, will, with a slight increase in the height of the head, hold up a casting of the same diameter and several times as long, provided the mold is inclined when poured.

At *D*, Fig. 1, a plan view of the finished drag of a mold is shown in which

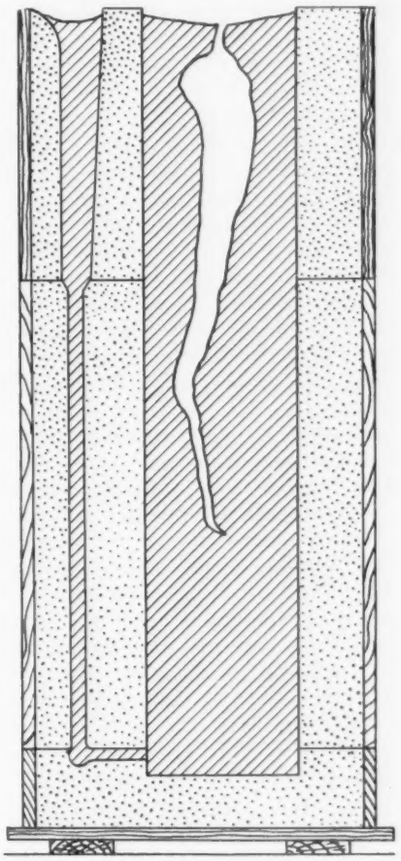


FIG. 2—SECTION THROUGH CASTING, RUNNER AND MOLD OF A BAR MOLDED ON END

are molded two solid bars, 14 inches long and 4 inches in diameter. The metal is carried into the mold by the sprue, *F*, which is connected to both feeders by a narrow gate, to enable the sprue to be kept full of metal while the mold is being poured. The sprue is 1 inch in diameter at the bottom, and it is an advantage to have it taper to 1½ inches at the top, as this makes it easy to choke the gate and to keep the head full of metal, thus holding back any dirt that may escape the skimmer. A longitudinal section of the mold through *A* and *B* is illustrated at *G*, and shows the appearance of the sprue, its approximate height and method of gating. It will be noted that the gate slopes sharply from the sprue to the casting, and is cut almost wholly in the cope, being merely dished out in the drag at the bottom of the riser. This is done more to remove any sand that may have been moistened by the swab when drawing the pattern, than for any other reason. The end of the bar with a section of the gate, is shown at *B*, Fig. 3, and it will be noted that the gate is comparatively small, so that it can be broken off the casting quite easily while the latter is hot. At *C*, Fig. 3, the dotted lines indicate the size of the gate very frequently used by foundrymen on such castings, who believe that it will prevent shrinkage. A gate of this size, however, is unnecessary, is difficult to cut off when cold, and if broken off

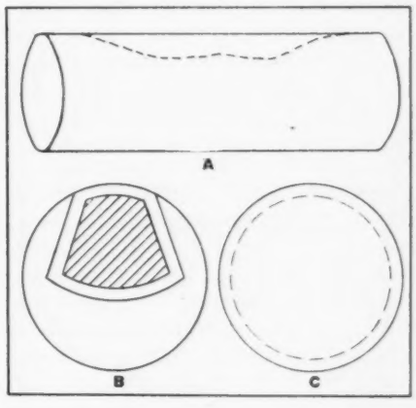


FIG. 3—DOTTED LINE IN *A* INDICATES SHRINKAGE; *B* AND *C* ARE SECTIONS OF GATES

while hot, the heavy blows required may injure the casting. If the feeder is too small the castings will shrink, irrespective of the size of the gate, and although in this case it may seem that a large amount of metal is used in the feeder, the end will justify the means, as by this method the bars will be solid and

no internal defects will be revealed when the bars are cut.

A modification of the method of gating outlined in Fig. 1 is advisable for copper bars over 2 inches in diameter, particularly when the copper is deoxidized with silicon, as in this case the metal must enter the mold as quietly as possible, to avoid drossing, otherwise imperfections will be found on the cope side of the bars. It is, therefore, always advisable to place the gate at the lowest end of the casting, as shown in the view of the drag, *D*, Fig. 1. To accomplish this, a long runner is used to convey the metal from the sprue to the bottom of the mold. The latter is inclined while being poured, and the metal runs up hill into the castings and afterwards fills the risers.

Fig. 2 is a section through the casting, runner and mold of a bar, 4 inches in diameter and 14 inches long, that was molded upright, and cast in copper, and shows how the metal piped through the sullage head, and half way the entire length of the casting. Several of these bars were cast in this manner and it was found necessary, in order to obtain a solid casting, to extend the head until it was the same length as the casting. It was subsequently found that better castings were obtained when they were molded horizontally and that less metal was necessary in the riser, and that time was economized both in molding and feeding the riser after it was poured. Bronze, however, does not shrink to the same extent as copper and solid bars of the size mentioned can be cast upright if it is considered desirable. The molds should be coated with plumbago, and afterwards polished to prevent the metal from cutting into the sand, and thus producing a rough casting.

The metal should be poured at a medium temperature, that is, neither boiling hot, nor dull and sluggish. If the sprues are broken off while the castings are hot, and if they are immediately cleaned, little will remain to be done to prepare the castings for shipment.

Bronze Melting and Pouring Temperatures*

By C. P. Karr

THE melting points of most of the common metals and binary alloys have been carefully studied by a number of physicists. Almost all of of these experiments, however, have been made in laboratories where every facility has been furnished and every condition fulfilled to make the determinations adequate and conclusive. The pouring temperatures, if they have been taken in foundries in accordance with foundry conditions and every-day practice, have not been published, so far as I can ascertain.

The experiments here described on the pouring temperatures of various bronzes, were conducted in January, 1911, in the foundry of the Nathan Manufacturing Co., New York City, and were made under foundry conditions in the course of the day's work, without any hindrance to the regular functions of the foundry. The melting temperatures could not be taken in the foundry itself without interfering with said functions, and, therefore, these determinations were made in the company's laboratories on four of the same type of metals from which the pouring tests, as recorded in Table I, were made.

The Fery radiation pyrometer was chosen as the instrument with which to undertake these tests. The temperatures given in Table I are relative and not absolute. Owing to the rapid formation of oxides on the surface of the molten metal a large number of readings were taken as the metal was poured into the flasks, with the expectation of securing a sufficient number of maximum coincident readings, that should more clearly indicate the pouring temperatures than an average of all the readings taken. No claim is made for exact accuracy of the temperatures recorded because they were made hurriedly under the ordinary regular foundry conditions familiar to every expert foundryman and because of these variable oxide films and surfaces. But it is believed that the drop in temperatures from the times of pouring from the furnace into the bull ladles or the foundry floor respectively, to the times of pouring into the last flask of a series poured, are relatively accurate. The times stated in the table were in every instance taken with a stop watch that indicated seconds on its large dial and automatically recorded minutes on its small dial.

Melting Temperatures.

In taking the melting temperatures in the laboratory "black body" conditions were applied as closely as possible, the metal was melted in a gas furnace supplied with compressed air. Temperatures were taken immediately after the blast was turned off, the metal stirred slowly but continuously until it cooled down to a pasty state and the pyrometer needle remained stationary for at least seven consecutive readings. The lowest consecutive coincident reading was then taken as the melting point of the alloy. As the amount of copper contained in the alloy has so much bearing upon the temperature of fusion, the type of the alloy is indicated in the table by its approximate percentage composition of copper.

The yellow brass used in the laboratory test was made from commercial sheet brass clippings. An analysis was made of the brass ingot after the melting test in order to determine whether it contained any constituent that would naturally lower the melting point of pure brass. It was found to contain about 68.8 per cent of copper, 0.19 per cent of lead and the balance zinc, with a trace of iron. For this composition the pyrometer indicated a melting point of 1,640 degrees Fahr., but on account of the heavy oxidation of the surface it is believed that this reading may be somewhat too low and particularly as the melting point of brass containing 70 per cent of copper and 30 per cent zinc was established at about 950 degrees Cent., or 1,742 degrees Fahr., by the examination of Haycock and Neville, the pioneer explorers in this field, although their composition contained no lead. The melting point of copper is taken to be about 1,084 degrees Cent., or 1,983 degrees Fahr. An independent reading of the No. 4 metal, not mentioned in the table, was taken in the laboratory and it showed a melting point of 1,850 degrees Fahr., a variation of 30 degrees from the figure given in the table, a variation due probably, either to a state of recalescence or to some variability in its composition.

It was desired to make a compari-

*Read at Pittsburg convention of the American Brass Founders' Association.

son between the drop in temperature of metal made in a coal-fired pit furnace and the metal made in a coke-fired tilting furnace. To do this all the conditions must be as nearly alike as possible. As the metal in the pit fires had to be brought from the furnace to the foundry floor in the pot in which the metal was compounded, the pyrometric readings had to be taken on the foundry floor directly from the pot itself after it was skimmed. To institute the same kind of reading with the metal from the tilting furnace poured into the bull ladle, the latter had to be skimmed and read at the floor level. As the composition of the metals compared differed from one another the average copper constituent had to be about the same is my belief that nothing conclusive can be drawn from the comparison for the reasons given below.

The graphite pots of the coal-fired furnaces and the fire clay lined bull ladles containing the metal from the coke-fired furnaces do not have the same emissive power and their coefficients of emissivity were unknown, and secondly the metal in the coal-fired furnaces was a hydraulic metal and it was difficult to keep its surface clear in taking the maximum readings. All the readings were taken with a Fery radiation pyrometer. E. C. Taylor, of the Taylor Instrument Co., Rochester, N. Y., assisted me by taking the focus on all the metals examined.

It was hoped for but hardly to be

tions and eutectic mixtures which have not been fully studied, this inter-action, so to speak, is so inseparably a part of the problem that nothing conclusive could be formulated.

To ascertain if a heat has been a good one it becomes necessary to make some well-known tests. No matter how great the skill of the foundryman may be, he cannot know that his heat has been a satisfactory one until these tests have been made. Although every other condition may be fulfilled, if the pouring temperature has not been right the heat will prove to have been unsatisfactory. The pyrometer is only a precautionary means to an end, but not a cure-all. If at the time the observa-

Table I.

Date of test, 1911.	Tilting furnace No. Pit furnace.	Metal No.	Approximate copper constituent, per ct.	Temperatures at furnace mouth. Focus on the pouring stream of metal.			Temperatures at foundry floor after pot was skimmed. Focus on face of molten metal.	Temperatures at pouring bench from pot to flask. Focus on stream of metal. Maximum reading.		Pouring time. From furnace floor.	Drop in temperature from pouring stream at furnace mouth to stream from pit.	Amount of metal poured per heat.	No. of degrees of temperature dropped per second.		Melting point.	Remarks.
January.				Degrees Fahr.	Number of readings.	Number of readings.	Degrees Fahr.	Number of readings.	Degrees Fahr.	Number of molds.	Minutes and seconds.	Minutes and seconds.	Degrees Fahr.	Pounds.	Degrees Fahr.	Number of readings.	Degrees Fahr.	
16	7	2	84	1,755	2	..	.....	18	1,700	14	5-0	...	55	450	0.488	20	1,650	
20	6	2	84	2,070	2	..	.....	8	1,840	8	4-4	...	230	450	0.942	..	.....	Cooled down by gates.
16	2	3	81	1,720	4	..	.....	14	1,650	14	3-0	...	70	450	0.436	..	.....	
18	8	3	81	1,770	2	2	1,675	10	1,600	23	6-6	5-6	170	450	0.556	..	.....	Time taken from furnace floor.
16	5	y. b	69	1,740	4	..	.....	7	1,670	10	1-55	...	70	450	0.608	14	1,640	Yellow brass.
18	5	6	88	1,990	2	2	1,970	8	1,940	5	3-0	2-30	30	450	0.161	..	.....	Time taken from
16	5	6	88	2,000	4	..	.....	8	1,940	8	5-49	...	60	450	0.172	17	1,820	foundry floor.
18	1	1	81	.....	..	2	1,850	14	1,800	14	...	3-55	50	450	0.212	..	.....	
18	2	1	81	1,850	2	..	.....	21	1,800	14	3-0	...	50	450	0.278	..	.....	
18	2	1	81	1,800	2	..	.....	19	1,735	14	6-36	...	65	450	0.184	..	.....	
18	Pit.	5	84	.....	..	2	1,900	10	1,800	10	...	3-25	100	190	0.488	..	.....	
18	Pit.	5	84	.....	..	4	1,992	10	1,750	10	...	6.0	242	190	0.806	..	.....	
18	Pit.	5	84	.....	..	2	2,113	10	1,890	10	...	5-0	223	190	0.743	..	.....	Cooled down by gates.
18	Pit.	5	84	.....	..	2	2,000	3	1,900	9	...	4-50	100	190	0.345	..	.....	Cooled down by gates.
18	Pit.	5	84	.....	..	2	1,880	9	1,840	9	...	3-6	40	190	0.215	22	1,735	
16	Pit.	5	84	.....	..	2	2,000	9	1,846	10	...	3-40	154	190	0.700	..	.....	Cooled down by gates.

and this condition was fulfilled. There were three heats in the coke-fired furnaces with six readings at the foundry floor level with an average of 1,832 degrees Fahr., and 32 readings at the pouring bench with an average of 1,780 degrees Fahr., or an average drop of 52 degrees. There were six heats of the metal in the coal-fired furnaces with 15 readings at the furnace floor with an average of 1,981 degrees Fahr., and 51 readings at the pouring bench with an average of 1,838 degrees Fahr., or an average drop of 143 degrees Fahr.

Although the mass of metal poured from the two types of furnaces was about the same in volume and notwithstanding the efforts made to equalize the mechanical conditions it expected that a comparison of the rates of cooling as shown in Table I would lead to the development of a theory that could be used in a practical way to express the drop in temperature of any given bronze alloy for a stated period of time, so that knowing the initial temperature the correct pouring temperature could be deduced, but so many conditions of foundry practice were involved and so few have been the experiments made, that such a law, if one there be, could not as yet be enunciated. Of course the basic metal of all bronzes is copper, and the inter-action of other metals upon copper itself and upon one another simultaneously, especially in combination with the complex formation of solid solutions are undertaken to establish the correct pouring temperature, the pyrometer readings are concurrently taken both as a check and as a record, and the trial is continued consecutively for at least one week to obtain simultaneous readings and concordant results, then the standard pouring temperature may be arrived at and the real value of the pyrometer will be recognized by readings concurrent with the standard thus obtained. The fluctuations of the needle, due to oxide films and slaggy surfaces, must constantly be borne in mind, and for this reason, if for no other, the maximum readings should be the only ones resorted to as a guide for the pouring temperature, and even this should be

compared with and confirmed by the melting point of the alloy in question, which should be established by some suitable laboratory method.

In 1909, in an address delivered before the Metallurgical Society of Birmingham, Eng., Percy Longmuir refers to the casting temperatures of some gun metal, yellow brass, red brass and Muntz metal, and the best specimens registered are given in Table II.

Table II.

	Casting temperature. degrees Cent.	Tensile strength, tons per square inch.	Elongation, per cent.	Reduction of area, per cent.
Gun metal	1,069	14.8	14.5	16.7
Yellow brass	1,020	12.7	43.0	35.6
Red brass	1,073	12.6	26.0	30.2
Muntz metal	973	18.9	15.0	16.1
In comparison, tests made under my direction were as follows:				
No. 1 metal	927	15.28	8.93	6.67
No. 2 metal	912	14.85	18.0	12.50
No. 3 metal	910	13.00	40.0	33.00
No. 4 metal	1,075	18.99	14.3	16.67
No. 5 metal	1,010	12.83	9.0	8.00
No. 6 metal	1,004	16.79	3.56	6.25

In the above table the No. 3 metal is a yellow brass; No. 4 metal corresponds to Mr. Longmuir's gun metal; No. 5 is of a lower grade than the other bronzes; No. 6 is a high grade hydraulic bronze and while showing a high tensile strength its elongation is small and it possesses proportionately a low percentage of reduction in area.

It has been suggested to me by an expert foundryman that the best way in which to make use of the pyrometer in the foundry for taking the pouring temperatures is to have the pyrometer set up in the foundry in a suitably protected structure and bring the pot to the pyrometer instead of carrying the pyrometer around with the pot to the great confusion and disgust of the caster. With this recommendation I most heartily agree.

Possible Uses of Rare Metals*

By W. R. Whitney

THE aim of this paper is not to describe what has been accomplished in the use of the rare metals, but rather to increase, if possible, the interest of experimenters in new alloys. I wish to call attention to the possibilities, in the way of useful discoveries, which, more than they realize may lie within reach of some of the members of this association, because of their particular knowledge or possession of special materials. For example, it frequently happens that one concern produces a new metal or alloy for some particular use, which, owing to lack of general study, may remain the sole use for a long period of time. Probably those who produce the special cerium-lanthanum-iron alloy used in the various types of friction cigar lighters have not been able to study very thoroughly the application of this alloy to other uses. So also, those who use the modern metals, tantalum, tungsten and molybdenum, have been engrossed with applications to a single field and have hardly been able to look carefully into others. It is often through the interchange of information, across the gap between quite remote fields, that useful advances are made.

It occurred to me that even an imperfect review of some of the relatively recent metals might not be amiss. Probably few realize the rapidity with which new metals are coming into use, particularly in alloys. There are approximately 50 metallic elements, though most of our important industries employ but a few of them. Some of these, in the metallic state, have market prices which are not yet controlled by the cost of production nor by the infrequency of occurrence, but rather by the lack of development of a utility. Beginning with gold, which we may assume is the one element whose exchange value depends upon its commonness in nature plus its cost of production, and passing over iron, copper, lead and zinc, whose values may be said to be well fixed by occurrence and costs of production, we soon reach other metals, for which a new demand might well greatly reduce the cost. Among these are many whose ores occur in abundance. In the case of this type of element the interest attached to research work is doubly great.

Copper and Aluminum.

It is highly improbable that the cost of copper will ever be greatly changed by the discovery of new uses. This is because the world's supply of the ore is pretty well known, the demands are high and the costs of production of metal from ore have been so studied that further reductions will probably be unimportant. This was not true of aluminum a few years ago, and it is still possible that considerably wider uses and reduction of production-costs may be developed in its future. There is, apparently, a much wider divergence between the occurrence of aluminum in nature, and its price in the metallic state than in the case of copper. In the case of aluminum, only selected and purified ores are used at present, while other compounds occur everywhere in nature. On the other hand, in the case of copper, ores containing even less than 2 per cent of copper are worked for the metal. Aluminum may thus still be considered in the transition state, a state long ago passed by copper and iron, and not reached by some of the metals to be considered. We have all been witnesses of the interesting advance of aluminum. From 1860 to 1874 its properties were becoming generally known. The inefficient process by which it was then reduced from its ores made it impossible to sell the metal below $10 per pound. Advances in reducing processes were then made, so that in the 80's the price was about $5. There was not a great demand for aluminum at this price. In 1907 approximately 26,000,000 pounds of this metal were made in America alone. The price is now about 20 cents per pound.

Calcium.

Calcium, which a few years ago was regarded only as a museum specimen and cost several dollars per gram, was sold in 1908 at $1.50 per pound, and could certainly be sold for a small part of this price if a greater use could be found for the metal. Its ores are found in abundance and it is only awaiting a commercial use. It slowly decomposes water and it differs from the alkali metals in producing such a feeble alkaline solution that it is generally harmless. It should serve as a good deoxidizer and it is not fair to relegate it to the list of useless metals.

Thallium is an element quite similar to lead, but probably possesses some property which will some day war-

*Presented at the Pittsburg convention of the American Brass Founders' Association.

rant its exploitation. It is softer and heavier than lead and could be obtained in quantity if a demand were created. Chromium, molybdenum, tungsten and tantalum, the latter three now obtainable in wire form, are tempting elements to study in mixtures with others. Who knows the useful properties of a chromium bronze, for example?

Tellurium has long been an apparently useless metal and any market price is fictitious, as but little is isolated in the metallic state. It is not necessary that a great use, such as a substitute for zinc in brass, should be found for it. Our industries are so great that if a pound of tellurium added to a ton of aluminum was of benefit to the latter, the production of the necessary tellurium would become a real industry.

Possibilities of Cobalt.

In the case of cobalt, the world's rate of supply of ore has been greatly augmented. It may take time to actually realize a greatly reduced cost of metallic cobalt, but it should be reduced when new uses have been developed. Our natural impulse, in such a case, is to try direct substitution of one metal for another in some well developed use. Cobalt, for example, might replace nickel in most uses when the cost declines below that of nickel.

Many tons of metal are annually consumed in making resistance wire for electrical purposes. At one time iron was the element generally used. German silver has replaced iron in some cases where a lower temperature coefficient is needed and where the increase in cost permits this. Now, there are a dozen or more special alloys for this particular electrical use. The new alloys have far outclassed the old in most of those properties for which the electrical engineer uses them. In such alloys nickel, chromium, manganese and other metals are now used in large quantities.

Increased Demand For Silicon.

Silicon, which in 1900 was a curiosity and sold for 40 cents per gram, is now a necessary component of special iron alloys and of high grade transformer iron, and thousands of tons of the alloy are used annually. Silicon is now sold at about 5 cents per pound. The use of this metal in other alloys is still quite limited. In the case of iron, it greatly decreases hysteresis loss and increases electrical resistance.

Boron is still an expensive material in the metallic state, but is coming into commercial use for making solid castings of high electrical conductivity.

Vanadium seems to be a young, wonder-working metal. Its use has increased very rapidly in the past few years, but the quantities consumed are not generally known. As several concerns are producing the iron alloy, it is safe to assume that it is now being sold in large quantities.

Cadmium.

Cadmium is a beautiful metal in many respects, and it is certainly awaiting use. It is whiter and less crystalline than zinc, and doubtless the high price of nearly a dollar a pound keeps practical workers from trying it in their experiments. It could be produced as cheaply as aluminum, if there were a good demand for it.

Titanium is a long-neglected element. It is a high-melting, ductile, white metal which, at present, is only separable from its ores at high cost. It exists in many cheap ores widely distributed in nature, and is now apparently coming into use in steel manufacture, particularly rails, and for this purpose it is fortunately unnecessary to isolate the pure titanium from its ores, as an iron titanium alloy is produced directly. What will happen when the pure element has been tried in special fields can only be surmised. If one omits the common alloys, brass, bronze, solder, etc., and considers only possible alloys of two metals, and further confines himself to 20 of the common metals, like vanadium, manganese, chromium, boron, etc., it is apparent at once that there must be hundreds of binary alloys. When, in addition, the effect of varying proportions in these alloys is considered, it becomes evident that the field of alloy-research is truly a large one. Many of the alloys, apparently still unstudied, are those which melt at extremely high temperatures.

The brass founder who knows the upper limiting temperature of his melting furnaces may at once point out that this temperature is fixed, both by the life of the crucibles and by the particular coke or oil-heating furnaces with which he is familiar. If he thought that a molybdenum bronze containing 80 per cent molybdenum, would have useful properties, he might conclude that he must give up this alloy because of the difficulty of melting it. If it were not for the advances in our available temperatures, there would seem to be little more than amusement in considering alloys high in tantalum, chromium, titanium, molybdenum, silicon, uranium vanadium and a number of other high melting metals, but hand in hand with the discoveries leading to the isolation of such metals, go also discoveries of aluminothermics, oxy-acetylene and oxy-hydrogen temperatures and electric furnace processes. The time is always ripe for the study of new alloys with new tensile strengths, elasticities, colors and wearing qualities. The automobile and the aeroplane have forced the aluminum and iron alloys to make rapid strides. The physical chemist has started a systematic coordination of certain properties of binary, and in a few cases tertiary alloys. He has shown how to plot a few freezing points of two-metal and three-metal mixtures and to construct therefrom curves showing not only all possible melting points of these metals, but what may be expected in the way of segregation and structure and such effects as are caused by annealing or quenching. He has found that there is a solubility of metals in one another which varies just about as the solubility of substances in water. Metals may be melted together and well mixed, but the quality and permanency of the mixture is determined by just such solubility laws as control ordinary solutions. We know that in some cases, well mixed, melted metals will separate into two layers if allowed to remain even a few moments in the molten condition at low temperatures. Two such metals are zinc and lead. They act like a mixture of water and ether. The two separated layers contain both metals, no matter what the temperature, but the quantitative composition depends on the temperature.

Solubility of Metals.

The other extreme of metal solubility is found in such a case as zinc-cadmium, which acts much like a mixture of alcohol and water, the two components going into solution in all proportions and remaining in solution at all temperatures. Having seen this analogy between the facts of solubility of substances in water, it is natural to search among the metal mixtures for all the peculiar kinds of solutions observed in aqueous solutions. Two classes include those corresponding to aqueous solubilities, where temperature widely influences the quantities dissolved, and those in which the solvent (as water) combines with the dissolved substance more intimately than by simple solutions, as by chemical combination. In the case of zinc and lead we have one of the metal alloys of limited solubility. If these two metals are well mixed in the liquid state, they

separate into layers, one, the zinc, carrying a few per cent of dissolved lead, floats on an alloy made up of lead carrying a few per cent of dissolved zinc. In general, the quantity of the one metal dissolved and held in solution by the other, depends on the temperature, and the higher the temperature the greater the solubility. Between 900 and 1,000 degrees Cent. they are apparently completely soluble. It follows from this that when two dissolved metals are cooled slowly, one of them may separate on cooling, if the limit of solubility is reached, and the extent of effective separation may depend on the rate of cooling.

The chemical combination between the metals is made most evident by the form of the freezing-point curve of the possible alloys. A compound of two metals which is stable at a temperature above the melting point of one or both of the metals, shows very clearly on the melting point curve and acts towards each of the elements just as a new or third element. Its melting point cannot be predicted from any knowledge of the component metals. It may even melt higher than either of the components. Such cases are seen in alloys of aluminum, lead-tellurium, etc. Man first used the metals as he found them; then, as he reduced them from the ores, and finally, when specific requirements became more and more exacting, he not only brought into use previously unused metals, but also greatly modified the old familiar ones; for a harder iron he used steel, a carbon alloy; for a harder steel, or one capable of cutting iron more readily, he added tungsten, nickel, chromium and other metals; for permanent magnets, molybdenum was added; for high electrical resistance nickel, chromium, etc., were added; for low electrical hysteresis, silicon and aluminum were added; for toughness in springs a little vanadium was used, and for wearing qualities titanium is now introduced. These are only a few of the successful alloying experiments with iron. They will probably be repeated with other metals, such as copper, zinc and aluminum, where the cost of the base metal is not high.

On the other hand, the study of those metals which have not yet advanced to a stage where cost reduction is impossible, is equally interesting. Consider again, the element, chromium. What do we know about it? Is it a workable metal? Can it be hammered or cast? Is it permanent in the air? Is there a considerable possible ore supply? Has the cost of obtaining the metal been reduced to what seems a reasonable price? etc. As it is unlikely that such an element will suggest itself for use by men as did copper and iron, it is probable that its properties must first be determined and made known. As a metal, chromium is only about 15 years old. It is made in the metallic state by reduction of the oxide by metallic aluminum and also by electrolysis of its salt solutions. It cannot be produced at a lower cost than that of the aluminum required, and it now sells at about 80 cents per pound. In the oxide from which it is made, it may be had for less than one-half this cost, and in alloys with iron, which are made by direct reduction with carbon, it is sold for 29 cents per pound. It is evident that ultimately, by perfection of metallurgical processes, etc., we may possibly obtain the metal much below 80 cents per pound. Chromium withstands heat exceedingly well. When pure it melts at a very high temperature, Ostwald states at about 3,000 degrees Cent., and it does not scale when heated red hot in the air. For this reason it is used in resistance alloys for electric heating devices. It has been plated onto metals, and then looks and acts much like nickel plate. Doubtless, its use will quite rapidly increase in special alloys, as it has already come into use in tool steel.

Alloys of Aluminum*

ALUMINUM is one of the most abundant of the elements, but it could not be obtained in large quantities before the advent of the electric furnace. It is manufactured by the reduction of bauxite at extremely high temperatures. The most interesting property of aluminum is its extreme lightness. Its mechanical strength is, however, low but it holds a high place in the ductility of metals. It is a good conductor of heat and electricity, its conductivity being about 60 per cent of that of pure electrolytic copper. In the form of a sand casting its tensile strength is only about five tons per square inch, as a rolled sheet about nine tons per square inch, while by hard drawing into wire its strength can be increased to 15 tons. The low density and other useful properties of aluminum have led to many attempts to improve its mechanical properties. The advent of the motor car and aeroplane have given an impetus to the aluminum industry, while ship building and the manufacture of cooking utensils open up other fields in which light alloys of strength and stiffness are extremely useful. The high ultimate strength of the copper-aluminum alloys was known to Dr. Percy, who is credited with their discovery. During recent years these alloys have been the subject of considerable study and it has been found that the addition of aluminum to copper causes an increase in both strength and ductility, the latter attaining its maximum with 7.45 per cent aluminum. Beyond this the tenacity increases, but the ductility falls. A remarkable similarity in microstructure and mechanical properties exists betwen the 9.9 per cent aluminum bronze and mild steel containing about 0.35 per cent carbon. Tests, which were conducted of the two metals, showed that the latter possessed a yield point of 15.2 tons per square inch, an ultimate stress of 38 tons per square inch, and an elongation of 26 per cent. On the other hand, the yield point of a 10 per cent aluminum bronze was 14.8 tons per square inch, ultimate stress 38.1 tons per square inch, and elongation 28.3 per cent.

The aluminum bronzes show a remarkable superiority in their resistance to corrosion over mild steel, and such alloys as Muntz metal and naval brass. A considerable difference was noted in the rate of corrosion between Muntz metal and aluminum bronze, and it was also found that Muntz metal corrodes at practically a constant rate, while aluminum bronze shows a considerable falling off in the rate of corrosion after a few months' service. As difficulty is experienced in obtaining sound castings from aluminum bronze, due to the formation of an elastic skin of alumina, defying all efforts to remove it, and which arises partly from the oxide dissolved in the copper and partly from atmospheric oxidation, it was thought that the difficulty could be lessened if the copper oxide were reduced before the aluminum was added, and, on account of the improvement effected in other alloys by manganese, this element was selected for the first experiments. Although improvements were effected, they were not as great as were expected. As a hardening agent in copper, manganese has the same effect as aluminum, but not to

*Abstract of a paper read before the Birmingham, England, branch of the British Foundrymen's Association, by Fred C. A. H. Lantsbury.

the same degree, as 3 per cent of manganese can be added to a 10 per cent aluminum bronze, and 5 per cent to a 9 per cent bronze, without seriously embrittling the alloy. The low aluminum-manganese bronzes were disappointing, but only those containing over 8 per cent aluminum can be regarded as possessing technically useful properties. An alloy containing 10 per cent aluminum and 2 per cent manganese can be hardened by cold drawing until it will cut stone, and should be found suitable for making bronze gear wheels, and for making cutting tools for explosives. If it possessed more elasticity it would, undoubtedly, prove valuable as a bearing metal.

Copper-Manganese Alloy.

In the preparation of the alloys it was found that thermite-manganese and ferro-manganese could be used directly, but considerable advantages are derived from starting from a copper-manganese alloy. This is done by melting copper under a borax slag saturated with oxide of manganese and afterwards adding the requisite quantity of manganese or ferro-manganese. The alloy is cast into small ingots, and for fine weighing and making-up, part of the alloy is granulated by pouring into water. In this way considerable refinement is effected. Starting from an 80 per cent ferro-manganese, the composition of the resulting alloy was as follows:

	Per cent.
Copper	66.14
Manganese	31.68
Silicon	0.014
Iron	1.86
Nickel	0.36
Carbon	0.053

Alloys prepared from this copper ferro-manganese contain about 0.31 per cent iron, which is not present in the alloys of thermite origin. The result appears to be a slight all-round improvement. Little need be said about the preparation of the actual alloys except that it is necessary to add the whole of the copper-manganese before adding the aluminum, and that the casting is best made in surface-dried, green-sand molds at as low a temperature as possible. As in the case of the aluminum alloys, the use of very large gates is necessary in order to insure soundness of the castings.

Table I.

Composition.

Copper, per cent.	Zinc, per cent.	Aluminum, per cent.	Yield point, tons per square inch.	Ultimate stress, tons per square inch.	Elongation, per cent.
70.0	29.6	0.0	3.6	8.7	50
69.0	29.9	0.4	2.9	12.6	59
70.0	28.8	0.9	4.2	14.4	67
70.5	26.4	3.1	8.5	21.5	50
70.1	24.7	5.2	4.7	32.2	11
60.0	40.0	0.0	5.1	20.2	47
59.6	40.1	0.3	6.2	20.5	51
59.9	40.3	0.8	6.0	19.6	45
59.6	38.5	2.9	7.5	29.2	14
60.4	35.9	4.7	11.3	28.0	2

Aluminum is almost an essential constituent of manganese bronzes, in which its function is that of a deoxidizer. An analysis of Parson's manganese bronze made some years ago by the author, showed copper, 56.72 per cent; lead, trace; aluminum, 1.78 per cent; iron, 2.20 per cent; manganese, 0.52 per cent, and zinc, 37.68 per cent.

Table II.

Composition.

Copper, per cent.	Zinc, per cent.	Aluminum, per cent.	Yield point, tons per square inch.	Ultimate stress, tons per square inch.	Elongation, per cent.
61.4	38.4	0.7	6.4	22.3	45
60.3	38.2	1.1	7.1	24.2	36
61.0	37.7	1.4	7.8	23.3	43
59.9	37.9	2.0	11.5	24.8	17
59.8	37.2	2.7	11.2	28.2	16
60.0	36.4	3.9	11.6	30.5	13

Aluminum Brasses.

Aluminum is often used as a partial substitute for zinc in brasses, its effects being to increase the hardness and tenacity with a reduction of ductility.

For most of our knowledge on the copper-zinc aluminum alloys we are indebted to Dr. Guillet, who states that one part of aluminum can act as a substitute for three and one-half parts zinc. Alloys containing over 4 per cent aluminum are difficult to cast soundly, but below this percentage the alloys give excellent castings suitable for pumps, valves, pinions and propellers. Further, the alloys forge and draw well. The effect of aluminum on sand castings of the 70 : 30 and 60 : 40 brasses is shown in Table I.

The effect of aluminum on the forging brasses, or those containing 40 per cent zinc, is shown in Table II.

These alloys have been rolled, drawn and annealed, and the tests bring out very clearly the improvements effected by the addition of 2 to 3 per cent of aluminum to the brasses.

The investigation of the alloys of aluminum and manganese alone gave results that were discouraging and the experiments were abandoned. The addition of such small quantities of manganese as 2 per cent destroyed the ductility of aluminum without adding to its strength. It was determined that manganese and aluminum formed a hard, brittle compound which appeared to be totally insoluble in aluminum, the effect being similar to that of sulphide of manganese on steel. Furthermore, this compound rapidly disintegrates and falls to a powder in the atmosphere. Upon the addition of copper, however, two of the alloys were found to give promising results, particularly when cast in chills, as will be noted from Table III.

By cold drawing the first alloy its yield point was raised to 11.28 tons, and its ultimate strength to 18.32 tons, the elongation falling to 6 per cent.

Interesting Tests.

Some interesting tests were made on the effect of casting temperature on the ultimate properties of the rolled bars. Two bars were cast at temperatures differing by 70 degrees Cent., and were afterwards rolled into bars. The mechanical properties of the resulting bars were identical, showing that the deleterious effects of casting at too high a temperature are completely obliterated by subsequent mechanical treatment.

The ability of these light alloys to resist shock is repeatedly called into question, and a series of tests were made with the Izod machine, which showed that the two alloys here described absorbed, respectively, 4.1 and 5.5 foot-pounds on fracture. Now a steel of 0.35 per cent carbon absorbs 4.5 foot-pounds, so considering the low tenacities of these alloys, in conjunction with the low densities, the results must be considered remarkable.

Corrosion of Light Alloys.

Experiments on the corrosion of the light alloys showed that the addition of manganese materially decreases the rate of corrosion, both in fresh and sea water. This is contrary to a general opinion that aluminum corrodes at a slower rate than its alloys. Possibly the manganese itself is oxidized, and its oxide adheres to the surface of the metal, producing a protecting patina of some

Table III.

Composition.

Copper, per cent.	Manganese, per cent.	Form.	Yield point, tons per square inch.	Ultimate stress, tons per square inch.	Elongation, per cent.
2.06	1.94	Sand casting.	5.8	8.48	4.0
		Chill casting.	6.4	9.05	5.0
		Rolled bar...	12.13	17.04	16.0
2.89	0.94	Sand casting.	6.0	7.48	5.0
		Chill casting.	7.27	12.05	13.5
		Rolled bar...	12.80	16.50	15.0

hydrated oxide of manganese. This tendency of manganese to increase the resistance to corrosion has been confirmed by Mr. Heathcote, who tried alloys of aluminum with iron, copper and zinc for a certain purpose, and found that all these alloys were worse than aluminum as regards resistance to corrosion. Ultimately an alloy containing 1.4 per cent manganese, 0.3 per cent of iron and 0.4 per cent silicon was found to resist corrosion in a satisfactory manner.

Aluminum-Zinc Alloys.

The aluminum-zinc alloys are undoubtedly best for casting purposes and are largely used for electric meters and similar work. The alloys used in motor car construction are essentially zinc alloys containing from 1 to 4 per cent copper. Shepard has shown that the zinc-aluminum alloys at each end of the series form what is known as solid solutions, that is, the metals remain dissolved in each other in the solid to a high degree, and from comparison with the brasses and bronzes, it would be anticipated that such alloys have a wide range of utility. The good casting qualities of the aluminum-zinc alloys are attributed to the fact that zinc increases the fluidity and decreases the surface tension of molten aluminum. According to Professors Turner and Ewen, these alloys expand slightly on solidification, which is particularly noticeable when they contain from 40 to 60 per cent of aluminum. The tenacity of aluminum is rapidly increased by the addition of zinc until at 50 per cent it reaches the maximum of 17.8 tons, and then falls to that of pure zinc. With 20 per cent zinc an aluminum-zinc alloy has a strength of about 15 tons per square inch with an elongation of 5 per cent in 2 inches, and in the light of our present knowledge, the 20 per cent alloy is probably the most useful of the aluminum-zinc series.

Dr. Guillet divides the aluminum alloys into two series, those containing 15 per cent zinc, which cast well and are very malleable, and those containing 30 per cent zinc, which produce fine castings but will not forge or draw. For most engineering work the zinc is supplemented by copper, and typical alloys are those containing 10 to 12.5 per cent zinc with 2 to 3.5 per cent copper. Such alloys have a density of about three and produce good, clean sand castings, that have a tensile strength of from 10 to 12 tons per square inch. A ternary alloy, for which great strength is claimed, is macadamite, which contains zinc, 24 per cent; copper, 4 per cent, and aluminum, 72 per cent. In the form of chill castings it has a tensile strength of 20 tons per square inch.

Magnesium appears to be an ideal element to add to aluminum, primarily because of its lightness, its specific gravity being only about 1.7, and secondly because of its power as a deoxidizer being greater than that of aluminum itself. The alloys were first discovered by Wohler in 1866, later by Parkinson in 1867, but the first to investigate them thoroughly was Dr. Mach, who called the metal magnalium. The alloys examined contained from 10 to 30 per cent of magnesium, and the harder ones are capable of taking a very high polish, capable of rivaling that of pure silver. Further, the alloys show a high resistance to atmospheric influences and retain their polish for a long time. Consequently they find application in the manufacture of scientific instruments.

Between 15 per cent magnesium and 15 per cent aluminum, the alloys are too brittle for constructional work, for which purposes magnesium is usually used in conjunction with other metals. Two alloys which find some application in the arts are as follows:

	Per cent.
Copper	1.76
Nickel	1.16
Magnesium	1.60
Aluminum	95.58

and—

Copper	0.21
Lead	0.72
Tin	3.15
Magnesium	1.48
Aluminum	94.34

Castings of the second alloy possess a tensile strength of from 14 to 21 tons per square inch. Both alloys work well and in drawing require to be frequently annealed, followed by rapid cooling. Tin is said to reduce the shrinkage, enabling sharp castings to be made.

Aluminum-Nickel Alloys.

Nickel behaves like copper, but the high nickel alloys possess, like the manganese alloys, the property of falling to powder after an interval of time. Alloys containing above 5 per cent nickel are brittle, but a 2 per cent alloy casts and rolls well, giving sheet with a strength of 12 tons per square inch and an elongation of 20 per cent. It is claimed, however, that in the construction of the Defender, an aluminum-nickel alloy having a tensile strength of 30,000 to 45,000 pounds per square inch, and an elongation of 10 per cent, was used. The alloys rapidly corrode in water.

Tungsten appears to be a useful element to add to aluminum, especially for alloys which have to be rolled into sheets, etc., and a most interesting alloy of this nature is Wolframium, which appears to have the following composition: Copper, 0.357 per cent; tin, 0.015 per cent; antimony, 1.442 per cent; tungsten, 0.038 per cent, and aluminum, 98.040 per cent.

Duralumin.

Duralumin was originally discovered in Germany. The alloy is not especially suitable for castings, but it finds its main uses in the form of wire and sheets. It is claimed that the material can be obtained in strengths varying from 26 to 40 tons per square inch with elongations varying from 3 to 21 per cent and Brinell hardness numbers of from 100 to 174, according to the degree and manner of working. The alloy is capable of taking a very high polish and resists atmospheric corrosion very well. The author has made several analyses of the material and its mean composition appears to be as follows: Copper, 3.58 per cent; silicon, 0.53 per cent; iron, 0.63 per cent, manganese, 0.43 per cent, and aluminum, 94.87 per cent.

There are also indications of the presence of magnesium, which has possibly been used as a deoxidizer. Other analyses show somewhat less manganese and more magnesium, one authority giving the magnesium content as high as 0.75 per cent. Apparently there is some variation in the composition, but the writer has never been able to detect so large a quantity of magnesium in any of his samples. Tensile tests on a sheet of the material, 0.082 inch thick, showed that it had a yield point of 56,000 pounds, an ultimate stress of 66,000 pounds per square inch, with an elongation of 2 per cent. A wire 0.057 inch in diameter broke at 180 pounds, equal to a tenacity of 70,500 pounds per square inch. A sample of the sheet after boiling in water for four hours appeared to yield from the commencement of loading and finally broke under a stress equal to 58,500 pounds per square inch, with an elongation of only 3 per cent. After annealing at 260 degrees Cent. for half-an-hour the strip showed a tenacity of only 51,200 pounds per square inch, with an elongation of 3 per cent. The wire after annealing at 260 degrees Cent. for half-an-hour broke at 160 pounds, equal to a tenacity of 63,000 pounds per square inch.

The addition of a small percentage of cadmium to low grade German silver will increase its hardness, color and general working qualities to that of a first-class alloy, containing from 22 to 30 per cent of nickel. The following alloy is recommended: Copper, 57 per cent; nickel, 12.5 per cent; zinc, 28.5 per cent, and cadmium, 2 per cent.—W. R. Barclay and J. Rodgers in the *Society of Chemical Engineers Journal.*

Brass Foundry Difficulties

SOLVED BY EXPERTS

Bronze for Valve Seats

Would you kindly favor us with a formula for a bronze suitable for hot blast valve seats that will withstand 150 pounds pressure, the metal being ½-inch in thickness?

The following formula will be found satisfactory for this purpose: Copper, 70 pounds; yellow brass clippings, 20 pounds; tin, 7 pounds, and lead, 3 pounds. Melt the copper under a cover of charcoal, add the yellow brass, stir the mixture thoroughly and then add the tin and lead.

Alloying Cadmium and Aluminum

What is the best method of adding cadmium to aluminum, so that it will not blow the metal out of the crucible?

The usual method of adding cadmium to aluminum is to place an asbestos cover on the crucible of molten aluminum after it has been removed from the furnace. This cover is provided with a small hole, through which the cadmium is dropped, and as the latter is made in sticks of lead pencil size, the hole in the cover need only be small. It is probable that the metal will be blown out of the crucible in spite of these precautions, and as it is doubtful whether it is any better than zinc for this purpose. We advise the use of magnesium, as this metal possesses some value as a deoxidizer of aluminum.

Tobin and White Bronze Mixtures

We would like to obtain an analysis of tobin bronze. The metal we are acquainted with under that name appears like gun metal, and the mixture we make is as follows: Copper, 59 per cent; zinc, 38.40 per cent; tin, 2.16 per cent; iron, 0.11 per cent; lead, 0.31 per cent. It is our opinion that this alloy contains too much zinc. We also have frequent requests for white bronze castings for automobile bearings, but have been unable to obtain satisfactory results from our own mixtures. Can you assist us in this matter?

The mixture of tobin bronze you mention does not contain too much zinc, as an excellent alloy can be made by adding 40 pounds of pure zinc to 55 pounds of copper and deoxidizing the alloy with 2 pounds of yellow prussiate of potash, and just before pouring add 1 pound of 5 per cent phosphor tin. The zinc in this alloy is considerably higher than in the example you give. The analyses of two tobin bronzes are as follows: (1) Copper, 58.22 per cent; zinc, 39.48 per cent; tin, 2.3 per cent. (2) Copper, 57.55 per cent; tin, 1.49 per cent; zinc, 40.02 per cent; iron, 0.38 per cent; lead, 0.56 per cent. Another alloy is copper, 56 per cent; zinc, 41 per cent; iron, 1 per cent; manganese copper, 2 per cent. White bronze is an alloy of tin, zinc and copper, principally, a typical analysis being tin, 65.12 per cent; zinc, 31.71 per cent; copper, 2.87 per cent; iron, 0.13 per cent; lead, 0.17 per cent. The iron and lead are probably impurities. Another alloy is as follows: Tin, 65 per cent; zinc, 30 per cent; antimony, 2½ per cent; copper, 2½ per cent. A cheaper alloy is: Zinc, 80 per cent; tin, 24 per cent, and copper, 4 per cent.

Bronze Pump Castings

Bronze pump castings which we are now making, when bored, reveal blow-holes. The castings are gated at the lowest point in the mold and a riser is used to insure sound metal. We use a fine grade of sand, and believing that it might be too close and the cause of our difficulty we tried a coarser grade, but without success. We have tried to obtain sound castings in green sand, dry sand and skin dried molds and have also used salt and charcoal on the metal, but the blow-holes still persist. Our experience is unusual in view of the fact that in the last three years our losses on these castings averaged only 2 per cent. The castings are subjected to hydraulic test and weigh 28 pounds each.

This trouble seems to be caused by shrinkage arising from the use of a riser that is too small for the casting. We suggest experimenting with a heavier riser, which should be straight and of the same diameter as the thickness of the casting. If the size of the mold will permit, it should be clamped instead of weighted and the riser should be built-up above the cope by placing on a head. Make the mold of the coarser grade of sand and coat it with plumbago. Pour the metal when it appears bright, not cold and dull, and when the mold is filled put sand on top of the sprue, bed on a weight and fill the riser with hot metal, which is fed as long as the riser continues to sink. This will, in all probability, prevent the trouble, but for small castings which will not permit of weighting the molds and the use of a riser, increase the diameter of the riser and make it straight and blind, that is, do not let it cut through the cope. An easy method of doing this is to put a frame on the cope after the mold is made and to carry the sprue up through the frame, widening out the head as usual. This makes the head higher than the riser and puts pressure on the latter, while the cover of sand keeps the metal in the riser hot, thus increasing its efficiency as a feeder. If this does not prevent a recurrence of the trouble, add phosphorus to the metal in the form of phosphor-copper (1 to 2 per cent). If sound castings do not result try this alloy: Copper, 67 pounds; tin, 8 pounds, and yellow brass clippings, 25 pounds. Melt one ingot of copper under charcoal, add the brass clippings, then the balance of copper; next add 2 inches of stick phosphorus, and lastly the tin; stir thoroughly.

The occurrence of this difficulty, after producing these castings successfully for so long a period, may be due to some change either in the metal or the method of molding. The metal may be influenced by traces of impurities which increase the shrinkage, or the riser may have been changed, and one slightly smaller in diameter, or having more taper has been substituted. If the latter is the case, the heavier feeder will effect a cure. The cause of these difficulties is often obscure and exceedingly difficult to locate, but they can be overcome by judicious experimenting. Thus far your investigations appear to have been confined chiefly to the sand, and as you have proved that this is not responsible, turn your attention to the riser and use care in melting the metal.

INFLUENCE OF MANGANESE AND SILICON*

A discussion of the remarkable effects of these elements upon gray iron --- Chilling cast iron car wheels

By Alexander E. Outerbridge, Jr.

IN ORDER that the progressive foundryman may clearly comprehend the remarkable influence that manganese and silicon and a few other elements exert (even when present in extremely minute quantities sometimes) upon iron, it is necessary that he should realize, at the outset, that iron, when pure, is always the same, physically and chemically, no matter from what source it may be obtained, and that all of the multitudinous variations may be traced directly to the effects of combinations with a few other elements. In its pure or nearly pure condition, iron is an exceedingly ductile metal which may be forged and hammered, or rolled, into very thin plates, ribbons or bars. The tensile strength is comparatively low, being approximately 50,000 pounds per square inch and the metal melts at a temperature between 3,000 and 3,500 degrees Fahr.

The addition of a very small amount, or less than one-half of 1 per cent of carbon, lowers the melting point several hundred degrees and converts the metal into what is known as "mild steel", changing many of its characteristics and greatly increasing its tensile strength. The addition of 1 per cent of carbon gives us high-grade carbon tool steel, having a tensile strength frequently of upwards of 150,000 pounds per square inch, and possessing other valuable properties.

Manganese in Foundries.

Manganese is a metal that for many years was regarded as a deleterious material which ruined the quality of iron or steel, yet this metal proved the salvation of the Bessemer process, and more recently Hadfield discovered that the addition of manganese in larger quantity than had hitherto been deemed permissible gave us "manganese steel", one of the most wonderful products known to man, possessing the rare combination of extraordinary strength, hardness and ductility.

About 30 years ago, I commenced a long series of investigations with this element in connection with the special kind of cast iron used for making chilled cast iron car wheels. Formerly such wheels were made entirely from cold blast charcoal iron, a product peculiarly suited for the purpose. This metal was rich in carbon and comparatively poor in all of the other elements. Good car wheel iron has approximately the following composition: [1]Carbon, 3.242 per cent; phosphorus, 0.403 per cent; silicon, 0.776 per cent; manganese, 0.391 per cent; sulphur, 0.083 per cent.

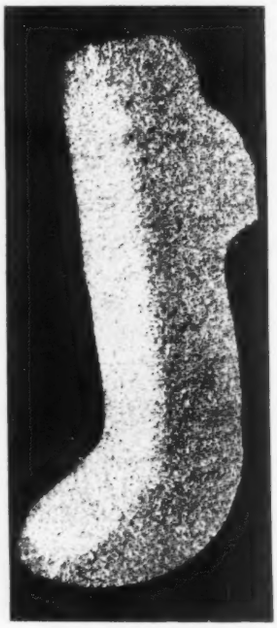


FIG. 1—SECTION OF A 33-INCH CAR WHEEL CAST FROM TREATED IRON SHOWING FINE WHITE CRYSTALS AND DARK GRAY IRON

Cast iron for chilled car wheels differs from iron for machinery castings or for general purposes mainly in its comparatively low silicon content, being less than one-half of the amount of silicon ordinarily found in iron castings and less than one-third the quantity often found in light castings, such as pulleys. Nevertheless, the silicon in these good wheels was close to the maximum amount permissible in chilled cast iron car wheels having the requisite depth of chill (or white iron) in the tread to insure high mileage.

The chilled cast iron car wheel is an American invention and the name of Asa Whitney[2] will always be inseparably associated with its history as a pioneer in its development and in its successful introduction in the early days of railroading.

As long as cold blast charcoal iron was obtainable, little difficulty was experienced in maintaining the product up to the required standard, and it is a remarkable fact that years before the chemical composition of the metal was studied or chemical analysis was used in preparing the melts, wheels were made, in which the silicon (which is the most important element of all) did not vary as much as one-half of 1 per cent from the average amount found by Dr. Dudley in the five good wheels, the explanation being that the foundry foreman was provided with a physical analysis of his metal in the form of chill tests made from every tap of the cupola. By this means the required depth of chill was maintained day by day.

Use of Warm Blast Iron.

In course of time, cold blast charcoal iron became more and more difficult to obtain and warm blast iron was introduced for economy both in the quantity of charcoal fuel and in the time required for reducing the iron from its ore. Instantly the quality declined and then hot blast iron, made with anthracite coal, supplanted charcoal iron for almost all purposes, even the making of chilled cast iron car wheels. This change in practice necessitated the introduction of more scientific methods in car wheel foundries.

It was well known that manganese caused iron to chill, and in 1880 the custom of introducing a certain quantity of high manganese iron into the cupola in car wheel mixtures had already attracted attention. The tests

*Presented at the Pittsburg convention of the American Foundrymen's Association.

[1]The late Dr. Charles B. Dudley, former chemist of the Pennsylvania Railroad Co., generously permitted me to copy this analysis from his private records on the occasion of a visit to his laboratory in Altoona in 1881. The record states that this is the average analysis of drillings from five good wheels, which had given the remarkable average mileage of 122,463 miles in service. The average depth of chill in the throat was 3-32 inch and in the tread, 11-32 inch. The average tensile strength of the pieces cut from the gray iron in the wheels was 29,660 pounds.

[2]Born 1791, died 1874; Mr. Whitney's basic patent for annealing chilled cast iron car wheels was issued in 1847.

which I was called upon in that year to make convinced me that a manganese chill on the tread of a car wheel was a spurious chill, very handsome to look at, but poor in wearing properties. The crystals are coarse and lamellar, they *spall out* or break away from each other when subjected to repeated taps with a hand hammer. Moreover, the white iron caused by high manganese in a chilling mixture is comparatively soft and may be drilled without great difficulty. The result of introducing high manganese irons in the cupola proved disastrous in car wheels when put to severe practical tests and the rule was, therefore, made that a manganese chill must be avoided.

Use of Ferro-Manganese.

In the course of these early investigations, however, a remarkable discovery was made, almost by accident. I found that if a very minute quantity of powdered ferro-manganese was placed in the bottom of a ladle and ordinary car wheel iron poured upon it several curious things happened:

First, a very rapid circular movement, or rather motion in ripples from the edge towards the center of the ladle, was immediately noticeable on the surface of the molten iron. This continued until the iron set, and was even apparent in the gates and risers of castings up to the moment of congealing.

Second, when a chill test piece was fractured it was seen that the gray iron portion was very much darker in color and of more open grain than that of a similar test piece poured from the same iron untreated.

Third, the white iron or chilled portion of the test piece showed no appearance of a manganese chill, the only visible change being a slight reduction in the depth of the chill. Test bars were cast from this metal and also from the untreated iron. An average gain approaching 50 per cent in tensile and transverse strength was recorded.

Analyses were made by various chemists of drillings taken from the treated and the untreated iron. These all showed that the principal change caused by the treatment had taken place in the condition of the carbon, nearly one-half of the combined carbon had been changed to the graphite form. The sulphur was likewise decreased. The shrinkage of the test bars of treated iron was reduced nearly 30 per cent as compared with the same iron untreated. Various proportions of ferro-manganese (containing about 80 per cent manganese) were tried, with the final result that the rule was adopted that in each ladle, holding about 600 pounds of iron, needed at that time to pour one full size, 33-inch car wheel, 1 pound of powdered ferro-manganese should be used. For a number of years this method was adopted only in the car wheel works of A. Whitney & Sons, Philadelphia, but in the course of time it became generally known and used, and although my connection with work of this nature ceased in 1887, I believe the method is still very generally, if not universally employed.

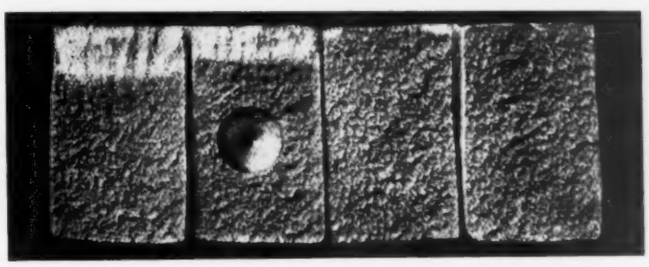


FIG. 2—FOUR SPECIMENS CAST IN GREEN SAND MOLDS AGAINST A CHILL BLOCK, ON ONE FACE

In an address, given at the Franklin Institute in 1888, entitled "Pig Iron and the Relation Between Its Physical Properties and Its Chemical Constituents", printed in the *Journal* of the Institute in March of that year, I made my first public announcement of these investigations, as follows:

Manganese is commonly supposed to exert a hardening tendency upon pig iron, but experience has taught me to regard this as another mistaken notion, it undoubtedly produces a marked effect upon the character of the white crystalline structure. You may readily recognize a manganese chill by its coarse lamellar or foliated filaments and by the tendency which it produces to form white iron or hard spots in isolated places throughout the gray portion of a casting. Manganiferous pig iron has been used to produce chilled castings, but it does not make a durable wearing surface; the chilled tread of a car wheel, for example, produced by this method, presents to the eye, when broken through the section, a handsome appearance, but the white metal is comparatively soft; it may be easily bored, and, what is more serious, it crumbles readily under the impact of rapid shocks on the rail.

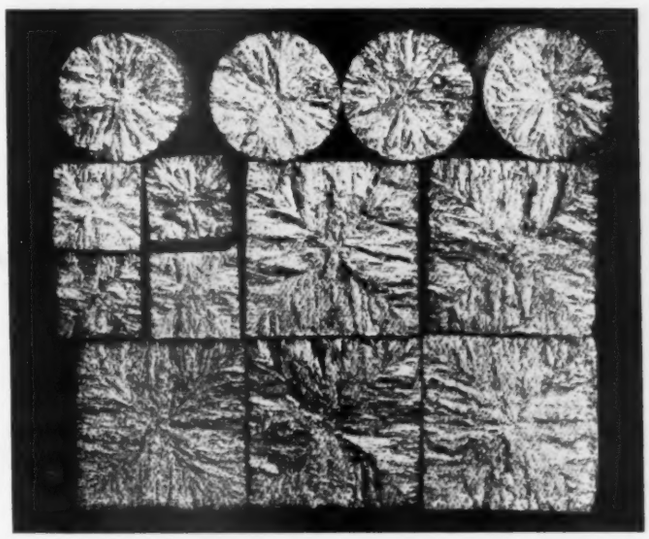


FIG. 3—SPECIMENS CAST IN HEAVY, IRON CHILL CUPS

A remarkable effect is produced upon the character of hard iron by adding to the molten metal, a moment before pouring it into a mold, a very small quantity of powdered ferro-manganese, say 1 pound of ferro-manganese in 600 pounds of iron, and thoroughly diffusing it through the molten mass by stirring with an iron rod. The result of several hundred carefully conducted experiments which I have made, enables me to say that the transverse strength of the metal is increased from 30 to 40 per cent, the shrinkage is decreased from 20 to 30 per cent, and the depth of the chill is decreased about 25 per cent, while nearly one-half of the combined carbon is changed into free carbon; the percentage of manganese in the iron is not sensibly increased by this dose, the small proportion of manganese which was added being found in the form of oxide in the scoria. The philosophical explanation of this extraordinary effect is, in my opinion, to be found in the fact that the ferro-manganese acts simply as a deoxidizing agent, the manganese seizing any oxygen which has combined with the iron, forming

manganic-oxide, which being lighter than the molten metal, rises to the surface and floats off with the scoria. When a casting which has been artificially softened by this novel treatment is remelted, the effect of the ferro-manganese disappears and hard iron results as a consequence.

Ferro-Manganese in the Cupola and Ladle.

It will be observed from the foregoing that manganese acts in two different and opposite ways in cast iron. When alloyed therewith in the cupola in considerable quantity, 2 per cent or over, it has a chilling and hardening effect, producing what I have termed a spurious chill of coarse crystalline nature, in contradistinction to the normal chill in a good car wheel which has a fine and closely interwoven crystalline structure.

When the alloy called ferro-manganese is added in a ladle of molten car wheel iron in the small quantity given (1 pound of alloy, containing about 80 per cent manganese, in 600 pounds of iron), it acts not as an additional contribution of 0.133 per cent manganese to the metal in the ladle, but simply as a deoxidizing and desulphurizing flux, cleansing the metal from impurities, softening it and greatly increasing the ductility and strength without injuring the chilled tread of the wheel.

It has been stated many times by others, during the past 20 years, that the introduction of this (unpatented) process proved of inestimable value in car wheel manufacture, especially when the very severe thermal test was devised by the Pennsylvania Railroad Co. and afterwards adopted by the M. C. B. Association, some time after my ferro-manganese method was published broadcast. It is a source of gratification to me to know that these early experiments proved of lasting practical value to a very important American industry.

Ferro-Manganese for General Foundry Use.

The fact that ferro-manganese was found to be so beneficial in car wheel practice soon led others to exploiting the alloy for general foundry purposes, but the conditions are here entirely different and in most cases this alloy is not only of no benefit, but is actually detrimental to foundry irons. I have already explained that it changes a large portion of the combined carbon in car wheel or chilled roll iron into the graphitic form, but this remarkable effect cannot take place in ordinary foundry iron which contains usually scarcely more than a trace of combined carbon. The ignorant and improper use of ferro-manganese in general foundries is sure to lead to disappointments.

An idea of the magnitude of the chilled cast iron car wheel industry in this country may be obtained from the following extract from an article by G. L. Fowler, on "Car Wheels", printed in *Cassier's Magazine*, March, 1910:

Roughly speaking, there are about 2,250,000 freight cars at present in service on American railroads. Each one of these is carried by at least eight wheels, whose standard diameter is 33 inches, so that the total number of wheels in service is in the neighborhood of 18,000,000, and their value, at the lowest possible estimate, $180,000,000. This refers almost exclusively to the cast iron wheel, which is still the one that is the mainstay of freight work, and which, until a few years ago, was the only one to be found under either passenger or freight cars. In short, it was upon the cheapness with which the cast iron wheel could be made that the very existence of many American railroads depended.

Car Wheel Industry.

This does not include cars in Canada, Mexico, Central and South America and the large number of freight cars belonging to private corporations. Moreover, the estimate given of 18,000,000 car wheels, having a value of at least $180,000,000 refers only to freight car wheels and takes no account of the enormous number of electric and mine car wheels, nearly all of which are made of chilled cast iron. This business has grown to immense proportions during the past 25 years and the use of ferro-manganese, added in small quantity in the ladles, has proved herein peculiarly advantageous and economical, since it permits the car wheel maker to cast all of these lighter wheels from the same mixture as is used for the heavy freight car wheels by simply softening the gray iron and reducing the chill to the requisite degree by varying the quantity of the alloy added in each individual ladle. Formerly it was necessary either to make separate melts for such wheels or to mix a certain quantity of soft iron, melted in a separate cupola, with the regular wheel mixture, which was too high chilling for lighter wheels.

When we consider the greatly increased weight upon the wheels, together with increased average speed of freight trains and far more severe action of the brakes in recent years, it is truly wonderful that the chilled cast iron car wheel should still be able to maintain its foremost place, notwithstanding the improvements made in steel wheels and great reduction in cost of their manufacture. The steel wheel will, in time, I believe, supersede the cheaper cast iron wheel for the severest freight service, but the day is far distant when the chilled wheel will no longer meet the general requirements for rolling stock except for locomotives and passenger cars, and it is my firm conviction that as long as cast iron wheels are manufactured, the use of a small amount of ferro-manganese, added in the ladle a moment before pouring, will continue to be a standard practice, for it has long since passed the experimental stage and the recent attempt to create an impression that the introduction in the ladle of a minute quantity of manganese in the form of ferro-manganese (less in amount than the natural variation found in good car wheels made by different manufacturers, or even by the same makers) produces an objectionable manganese chill, will fail to make any impression on intelligent persons who understand the subject and have practical experience in the business.

In a pure state, silicon may be obtained in three allotropic forms, quite different from each other in appearance and also in some other properties. In this respect it resembles pure carbon, which is found as *graphite, charcoal* and *diamond*. In the amorphous state pure silicon is a brown combustible powder. In crystalline form it has a red luster, and in so-called graphitic form it resembles graphite in appearance. In recent years silicon has been produced in commercial quantity nearly pure (98 per cent) by means of the electric furnace and is used in steel manufacture. Its melting point, however, is so high that it will not dissolve in molten cast iron in a ladle. Formerly silicon was regarded as a most undesirable element in pig iron for foundry use, it was thought to produce blow-holes and to make unsound castings.

Silicon for Foundry Use.

When the suitability of pig iron for castings was determined by fracture only, as was the case in my early foundry experience, *Silvery pig, Rotten pig* or *Measly pig*, as pig iron which was very high in silicon was variously called, was practically an unsalable commodity to foundries, for, when silicon is present in quantity ranging from 5 to 10 per cent or over, the pig metal becomes very brittle and hard, the fracture is very light gray in color and devoid of the crystalline structure characteristic of good metal. It is totally unsuitable for castings. I well remember the consternation among several foremen when I first introduced a carload of silvery pig iron containing 12 per cent of silicon to their notice and proposed to use a certain amount of it in the cupola mixture for the purpose of softening the iron and permitting a larger proportion of hard scrap to be incorporated, followed by their astonishment at the unexpectedly beneficial result in the melt. My records show that for several years this high silicon iron was purchased and used as a regular component in the foundry.

In course of time the views of intelligent foundrymen changed with re-

spect to silicon and therewith coincidently came a change in the practice of pig iron makers as well. No longer was it considered desirable to keep the silicon as low as possible in foundry irons. Gradually the average proportion began to creep up, so that it was not necessary for me to continue to purchase 12 per cent silicon pig iron in order to obtain the amount desired in our castings, for a sufficient number of brands of iron containing the full amount of silicon desired for our smallest castings could be obtained without difficulty at the ordinary market price of No. 2 plain iron. In fact, the pendulum has now swung the other way and I find it necessary to limit the proportion of silicon in pig iron purchases to suit various requirements.

Early Experiments With Silicon.

While experimenting with ferro-manganese added in ladles of car wheel iron many years ago, I desired to know the effect upon the metal of other similar alloys and therefore obtained the highest grades of silicon alloys then made irrespective of cost and the richest contained nearly 20 per cent silicon. It was a disappointment to find that even when this metal was powdered and preheated to redness the influence on the cast iron of the comparatively small amount that could be melted in a ladle of iron without making it dull was almost inappreciable. Similar tests were made with aluminum, which cost at that time $8 per pound, and the results were again disappointing.

These experiments were, therefore, discontinued until the progress in the art of electro-metallurgy had made it possible to obtain very high-grade alloys of silicon and iron, when they were at once resumed on quite an extensive scale. The results of many tests showed that if an alloy containing approximately 50 per cent silicon with iron is powdered and added in small quantity to a ladle of foundry iron (not over 1 pound of the ferro-silicon alloy in 200 pounds of iron, usually less than this) it melted readily without appreciably reducing the temperature and certain beneficial effects occurred. The metal became both softer and stronger. If, however, the molten iron already contains over 2.50 per cent silicon, there is little or no advantage to be obtained by adding this alloy in the ladle.

Ferro-Manganese and Ferro-Silicon.

The foundryman should understand clearly that ferro-manganese and ferro-silicon possess entirely different functions in cast iron and should not be used indiscriminately or in conjunction. Ferro-manganese is best adapted to the treatment of high-chilling iron for car wheels or chilled rolls, or other chilled castings, where the proportion of combined carbon is large. Ferro-silicon is best adapted to treatment of foundry iron when from any cause it is hard and brittle, since it possesses the peculiar property of softening and at the same time strengthening such iron. It also enables the founder to vary the grade of iron in individual ladles to suit individual castings or groups of castings. It gives the founder control of his iron after it has been withdrawn from the source of melting, a matter of great importance and value, and it enables him to use cheaper grades of iron. Finally, I wish to say that neither ferro-manganese nor ferro-silicon can be regarded as universal panaceas, and, while each in its proper place is of great value, they must, like all other good things, be used intelligently, and if impure adulterated materials are employed, they will not only prove to be of no benefit, but may be absolutely harmful.

Influence of Silicon on Iron.

The influence of silicon in softening pig iron and reducing its chilling property is clearly shown in Fig. 2. Four test pieces were cast in green sand molds, one face in each being formed with an iron block. The only important difference in composition between the specimens is in the amount of silicon in each. The one at the left contained 0.7 per cent silicon, the one showing a hole, where a drill had been used to obtain borings for analysis contained about 0.8 per cent silicon. The next contained a trifle over 1 per cent silicon, and the specimen on the right nearly 2 per cent silicon. In this case a mere skin chill is noticeable on the upper face against the chill block. The remarkable effect of cooling gray iron very suddenly is shown in Fig. 3. Here the molds are heavy iron chill cups; some are ½ inch section, 1 inch section and others about ¾ inch round section. All of these specimens are absolutely white iron. Samples of the same iron poured in green sand molds of about the same size were all perfectly gray in fracture. It will be observed that the white iron crystals always form at right angles to the chilling surface of the molds, presenting an appearance resembling spokes of a wheel in those of round section, and showing a cross at the nodal lines, or points, where the crystals meet, in the specimens of square section. The lines of demarcation are as sharply defined as though scribed with a tool on solid metal, and it is possible, in some cases, to split the specimens lengthwise along these lines. The specific gravity of the gray iron is about 7.2, while that of the white iron is nearly 8. There is, however, an appreciable difference in density of different specimens of white iron just as there is a well known difference in density of different specimens of gray iron. There is also a marked difference in hardness of white iron crystals.

Chemist in the Foundry.

At the time of my first introduction to foundry metallurgy, the total annual production of pig iron in this country was less than the minimum monthly production in recent years. The increase in capacity and daily output of blast furnaces, together with the change in the kind of fuel first from charcoal to anthracite, then to coke, the increase in the temperature of the blast, the decrease in fuel ratio, the change in character of ores, etc., have all caused radical changes in the composition and properties of pig iron and the old method of judging the character and grade of pig iron by fracture has now become obsolete. In my youth, a chemist in a foundry was generally considered as much out of place as a bull in a china shop, and my first effort to substitute scientific system for empirical methods was regarded by practical foundrymen with ill-concealed amusement as a passing fad. The old order of things has now passed away and a new one has established itself on a permanent footing. What further progress will take place in the next 30 years I can neither venture to predict nor expect to witness.

A friend, who kindly read the proof of this paper, returned it with the following, rather interesting, comments:

Estimated that the total number of chilled cast iron car wheels of all kinds made since the ferro-manganese process became known through your publication of March, 1888, in the *Journal of the Franklin Institute* and elsewhere, is at least 35,000,000 and assuming that an average of 1 pound of the alloy was used in the ladles for each wheel, the total consumption for this purpose was at least 17,500 tons. It was known, during the life of the Hamilton steeled wheel patent, that the Pennsylvania railroad, A. Whitney & Sons, and probably some other car wheel makers, paid royalties of 50 cents per wheel on all wheels of 300 pounds and over and 25 cents per wheel on those of lesser weight, for the privilege of melting from 5 to 10 per cent of steel scrap in their mixtures. Supposing that your process, instead of having been freely given as a scientific discovery, had been protected and that the very small charge of 10 cents per wheel had been collected on only one-half of the foregoing estimated number of wheels made, the total would have reached the very respectable amount of $1,750,000.

Car Wheel Production.

Regarding these interesting estimates and calculations, I have found it impossible to obtain any data as to the annual production of mine car wheels and street car wheels, but official fig-

ures of the United States Census bureau for 1900, show that there were 145,437 steam railroad cars built in that year, requiring 1,163,696 new wheels. It is, therefore, evident that an estimate of 35,000,000 wheels of all kinds cast in 23 years, must be considerably below the mark. The statements of the American Iron and Steel Association show that in five years, from 1905 to 1909, inclusive, the production and importation for consumption of ferro-manganese amounted to 616,356.45 long tons, an average of 123,271.71 long tons per annum, so that the quantity used for car wheels is a mere drop in the bucket.

The Growth of Cast Iron

PROFESSOR H. C. H. Carpenter discussed the growth of cast iron after repeated heatings, in a lecture recently delivered at a joint meeting of the Birmingham, Eng., Metallurgical Society and the Birmingham branch of the British Foundrymen's Association. In the course of his remarks Dr. Carpenter stated that when cast iron is subjected to repeated heatings it grows appreciably, while wrought iron or mild steel subjected to similar treatment, will contract. He discussed the work of A. E. Outerbridge, of Philadelphia, who has shown that a gray iron bar after being heated to 800 or 900 degrees Cent., about 35 times, increased in volume until it became 46 per cent larger than it was originally, while its specific gravity diminished from 7.13 to a trifle over 6. He did not agree, however, with Mr. Outerbridge as to the cause of this phenomena, and stated that his researches had shown the cause to be a chemical and not a purely physical one. In an earlier investigation Dr. Carpenter had taken several groups of bars and heated each one separately in a cast iron muffle to about 900 degrees Cent. for a number of heats, each of four hours duration. He found that white irons consisting of iron and carbon with only 0.15 to 0.25 per cent silicon and of any carbon content under 3.5 per cent, did not grow, even after 90 heats. With 4 per cent carbon the growth amounted to 7 per cent, with 3.5 per cent carbon the growth was 6.2 per cent, and he attributed the growth in these cases to the deposition of temper carbon, the separation of another constituent in the iron. In another group of bars in which the carbon was constant, while the silicon varied from 1 to 6 per cent, all the bars grew, the growth ranging in the order of the variation of the silicon from 15 to 63 per cent. All these irons, of course, were gray, the earliest in the series being close, while the latter bars became more open. The first sets of bars, after heating, preserved their cylindrical form, while those containing 6 per cent silicon practically fell to pieces. It was thus established that a fundamental factor in the growth of any gray cast iron was the percentage of silicon it contained, and it was noticeable that the bars grew more at the ends than in the middle, which he considered was due to the absorption of furnace gases by the iron. It was found that there was no constancy in weight with bars heated under similar condition, that the specimens increased in weight as the silicon contents increased, and also with the number of heats, and that those specimens which were cut from near the gate of the casting grew more quickly, and less uniformly, than those cut at some distance from the gate. This was also attributed to the gases in the iron.

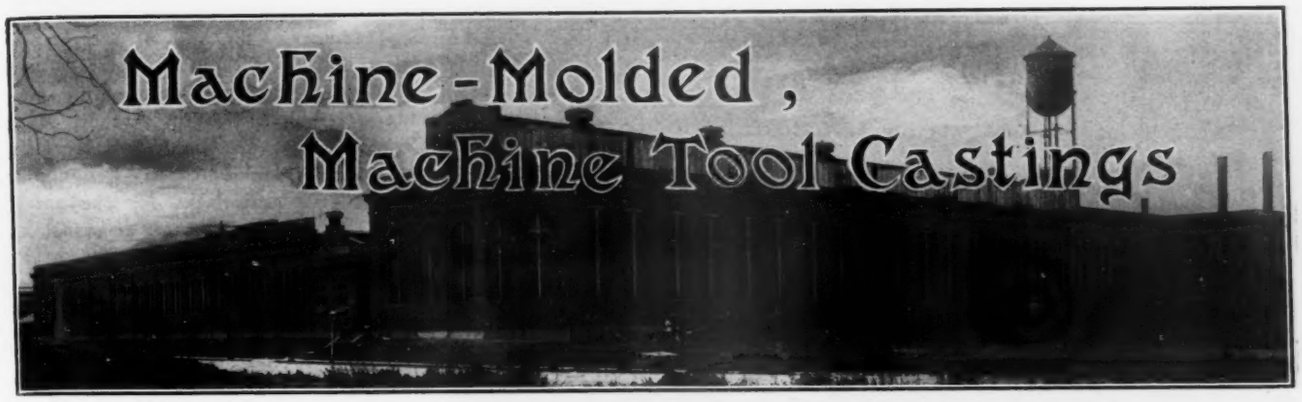
Increase in Weight.

A close connection was observed between the increase in the weight and the growth in the volume of cast iron after repeated heating. The silicon in the iron existed in the form of iron silicide and from that combination there separated, not only practically pure silica, but a certain amount of iron oxide, the amount of the latter varying with the amount of graphite in the casting. To establish the connection between the growth of cast iron and the penetration of furnace gases, circular bars of cast iron were each subjected to a different number of heats, after which sections were cut off, etched and examined, and it was found that the degree of penetration of the gases as evidenced by the development of porosity, increased with each successive heat in an iron with the following analysis: Carbon, 3.79 per cent; silicon, 2.96 per cent; manganese, 0.25 per cent; sulphur, 0.010 per cent and phosphorus, 0.012 per cent. A bar of iron was also heated in the air until it had grown 67 per cent and when afterwards heated in a vacuum it emitted a considerable volume of gas consisting of hydrogen and nitrogen, in the proportion of 7 to 1, after which treatment the bar, instead of developing further growth, actually shrank, which showed that the process of removing the gases from the iron did not itself cause any growth. After the gases had been abstracted from samples in this manner they were next heated in a muffle when they developed the enormous growth of 67 per cent with no cracking. These tests showed that the dissolved gases were the cause of the cracking and disintegration noted in earlier experiments.

These researches had so far shown that the graphite and silicon in the cast iron were essential to its growth and that manganese, sulphur and phosphorus either had a very slight influence on its growth or none at all. Dr. Carpenter was of the opinion that the reaction between the incoming gases and the iron took place when the latter was cooling, when the oxides of carbon, reacting with the iron silicide, formed silica and iron oxide. This formation, it is believed, produces cracks in the metal, and when again heated the gases enter these cracks and penetrate further into the iron, so that each time the iron is heated, the gases reach a little nearer to the center, producing more silica and iron oxide, and causing progressive deterioration of the iron, until the maximum growth is attained, when the material practically ceases to be a metal and behaves, under a saw, more like chalk. As a remedy for this difficulty he previously suggested the use of an iron containing about 3 per cent of carbon, low silicon, and small quantities of other elements, but it had been held that this iron was unsuitable for ingot molds for steel, as it would grow, and in his opinion it was not possible to so treat a gray iron that it would not grow, as the iron must contain sufficient carbon to be readily fusible. After working at this problem for 18 months he believed that a solution of the difficulty had been found. Dr. Carpenter said that the solution of the problem turned upon the quantity of manganese present in the iron. Manganese exerts an important influence on iron, as it keeps the carbon in the combined state and prevents the deposition of temper carbon. It also makes carbon irons less brittle.

White Iron Containing Manganese.

White irons were prepared containing a considerable amount of manganese, which, while not as fusible as ordinary gray iron, were very much more fusible than mild steel, and possessed the further valuable property that they did not deteriorate by repeated heatings, but were rather improved in their mechanical properties, particularly in tenacity. Irons made according to specifications developed by Dr. Carpenter, after being heated 150 times for four hours at 900 degrees Cent., had actually contracted from ½ to 1 per cent instead of having increased in size.



Machine-Molded, Machine Tool Castings

How these sections are made by the Modern Foundry Co.

AT OAKLEY, a suburb of Cincinnati, is located the Modern Foundry Co.'s gray iron shop, which is a subsidiary plant of the Cincinnati Milling Machine Co. The machine tool builders of the Cincinnati district, until recent years, bought their castings largely from local shops and from foundries in southern Ohio, and it was claimed that these castings could be purchased from jobbing foundries at prices below the manufacturing cost of these sections to a tool builder operating a plant devoted to the production of these castings exclusively. It was believed, however, that a large foundry especially equipped with labor-saving devices for the manufacture of machine tool castings, might effect economies that were not possible in some of the jobbing shops engaged in this line of work, and this led to the erection of the Modern Foundry Co.'s plant by the Cincinnati Milling Machine Co. In addition to furnishing castings to the parent concern, other manufacturers comprising the Oakley colony, draw upon this foundry for their gray iron sections. Other concerns, in addition to the Cincinnati Milling Machine Co. and the Modern Foundry Co., that have built plants at Oakley, are as follows: The Cincinnati Planer Co., Cincinnati Bickford Tool Co. and the Triumph Electric & Ice Machine Co.

The foundry is divided into six departments under one roof, the general layout being L-shaped. The plant is located several hundred feet in the rear of the works of the Cincinnati Milling Machine Co. and the Oakley central power station is located directly in back of the foundry. The general layout of the shop is shown in Fig. 10. In common with all the other Oakley colony plants, the power station furnishes the foundry with steam heat, water, compressed air, electric power, etc., the different lines being laid in an underground concrete tunnel. Fire protection is afforded by an automatic sprinkler system. Direct current motors are used for operating the blowers, sand conveyors, riddles and cranes, while compressed air is used for operating the molding machines and for furnishing the air to the oil burners installed by the Hauck Mfg. Co., Brooklyn, N. Y., which are used throughout the shop for skin-drying molds. Sanitary drinking fountains of the bubbling type are distributed throughout the entire plant, and shower baths, lockers and wash rooms have been installed for the convenience of the employes.

The buildings are of brick construction, stone-trimmed, and present a pleasing appearance. The foundry is 70 feet wide and 220 feet long and at one end of the shop is located the melting department. The charging floor is 160 x 22 feet. The core department is located directly under-

FIG. 1—GENERAL VIEW OF THE MODERN FOUNDRY CO.'S GRAY IRON FOUNDRY; ONE OF THE SAND CONVEYORS EXTENDS ALONG THE WALL AT THE RIGHT

FIG. 2—TWO SMALL SAND HOPPERS ARE SHOWN AT *A* AND A LARGE SAND HOPPER AT *B*

neath the charging floor and the core ovens are built outside of the foundry with doors leading into the shop. The iron is melted in two cupolas lined to 54 and 36 inches, respectively. The blast is furnished by a Piqua blower driven by a 30-horsepower motor. Large flasks are stored in the yard at the rear of the foundry.

Practically all of the molds for machine tool castings are machine-made. The machines for medium and light work are arranged along the wall at one side of the shop. A variety of molding machines have been installed and these include split pattern, plain power-ramming, roll-over and stripping plate types furnished by the Tabor Mfg. Co., Philadelphia, the Osborn Mfg. Co., Cleveland, and Henry E. Pridmore, Chicago. In the opposite side of the shop large molds are rammed by jolt-ramming molding machines installed by the Arcade Mfg. Co., Freeport, Ill., and the Herman Pneumatic Machine Co., Zelienople, Pa. Boards and flasks for the small casting floor that are not in constant use, are stored in the yard and great care is exercised to arrange the flasks according to size and form. All bottom boards are stacked in rows and each pile is designated, showing the sizes of the boards. For convenience in handling and to reduce the space required for storing the flasks used on the molding machines, the pipe handles are removed from the flasks and are only inserted when the flasks are used. The standard flasks for light work are 22 x 16 inches and 6 inches deep. Lugs are provided on the sides of the flasks for holding the handle bars. The light casting department is commanded by two hand-operated travelers, equipped with air hoists. The main bay is served by three electric traveling cranes, having a span of 40 feet.

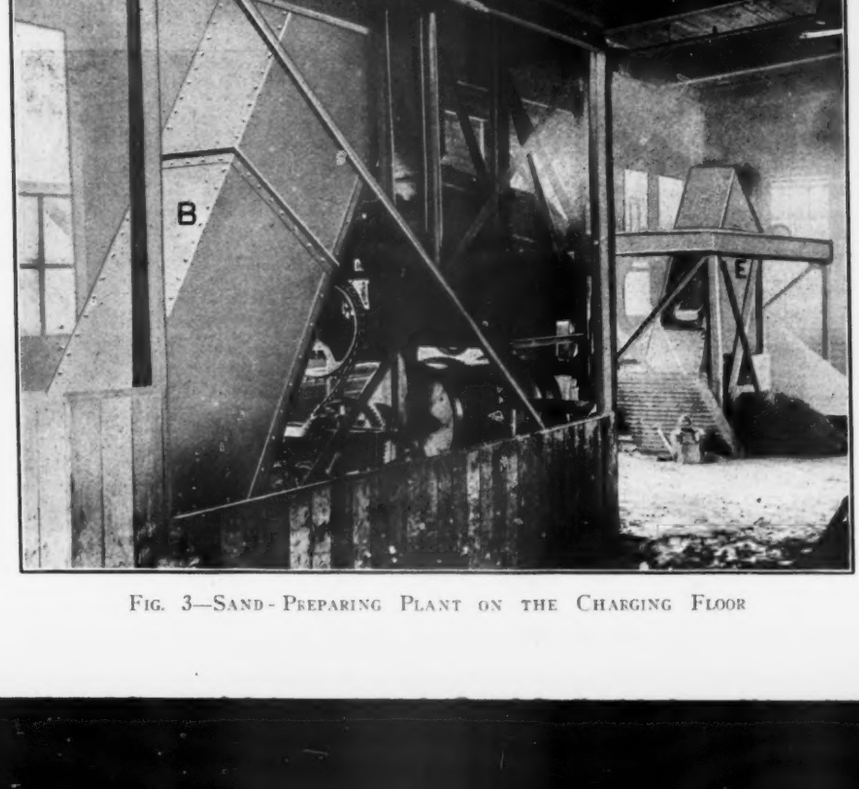


FIG. 3—SAND-PREPARING PLANT ON THE CHARGING FLOOR

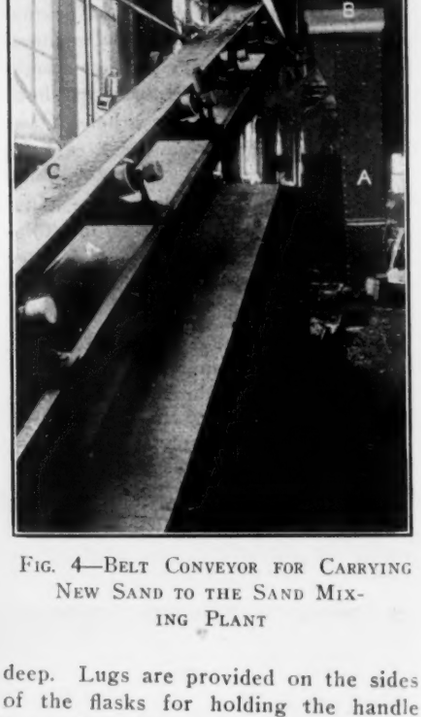


FIG. 4—BELT CONVEYOR FOR CARRYING NEW SAND TO THE SAND MIXING PLANT

In the core department a jolt-ramming molding machine is used for making practically all of the large cores, as shown in Fig. 5. The core boxes, filled with sand, are handled by electric hoists being supported by a double pair of hooks attached to a double-end bar, which engages the crane hooks. When ramming the core, these hooks are removed by lowering the crane hook, slightly, but are left

in position so that the core box can be quickly lifted from the table when the core has been rammed. The machine is surrounded by a concrete platform which extends about eight inches above the core room floor. In addition to the two large core ovens shown in Fig. 6, four small ovens have been installed for light cores. The method of handling core plates by an electric hoist is clearly shown in Fig. 6.

Sand Handling Equipment.

Sand is delivered to the various molding floors by sand conveyors installed by the Jeffrey Mfg. Co., Columbus, O. Two 12-inch scraper conveyors extend along the walls on either side of the building and discharge sand into small storage hop-

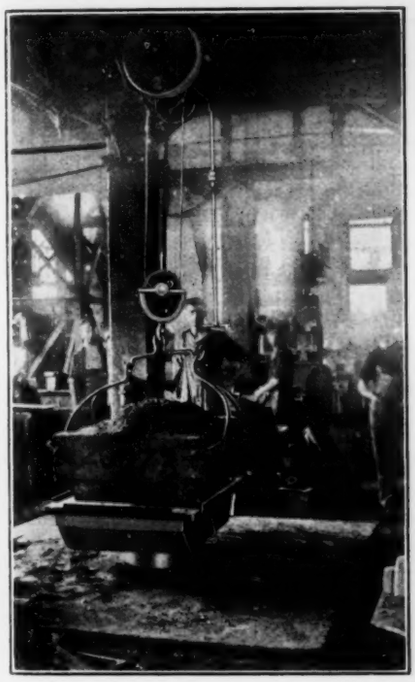


FIG. 5—JOLT-RAMMING MACHINE FOR RAMMING LARGE CORES

pers at each molding machine and bench. The sand conveying apparatus has a capacity of about 10 tons per hour. One of the sand conveyors is clearly indicated at the left in Fig. 1, which also shows the chutes through which the sand is delivered to the molding floors. In Fig. 2 are shown small hoppers at *A* and *B* is the large sand hopper which serves one of the jolt-ramming molding machines, the table of which is indicated at *D*. Each scraper conveyor extends the full length of the shop at a height of about 10 feet from the floor and is operated by an electric motor, this operating mechanism being shown in Fig. 9. A railing and walk extends the full length of the conveyors for

FIG. 6—A VIEW OF THE CORE DEPARTMENT, SHOWING THE CORE CARS AND THE LARGE CORE OVENS

the convenience of the workman in charge of this equipment. Fifteen sand hoppers serve the small molding machine floor, while in the jolt-ramming machine department there are 12 sand hoppers. The small sand hoppers are of steel construction, squared at the bottom and are reinforced at the lower edges for the adjustment of wooden plates for closing the hoppers if desired.

The flasks are shaken-out by a night gang, which also mixes and tempers the sand. The sand, when shaken-out of the flasks, falls through gratings in the foundry floor, onto 12-inch belt

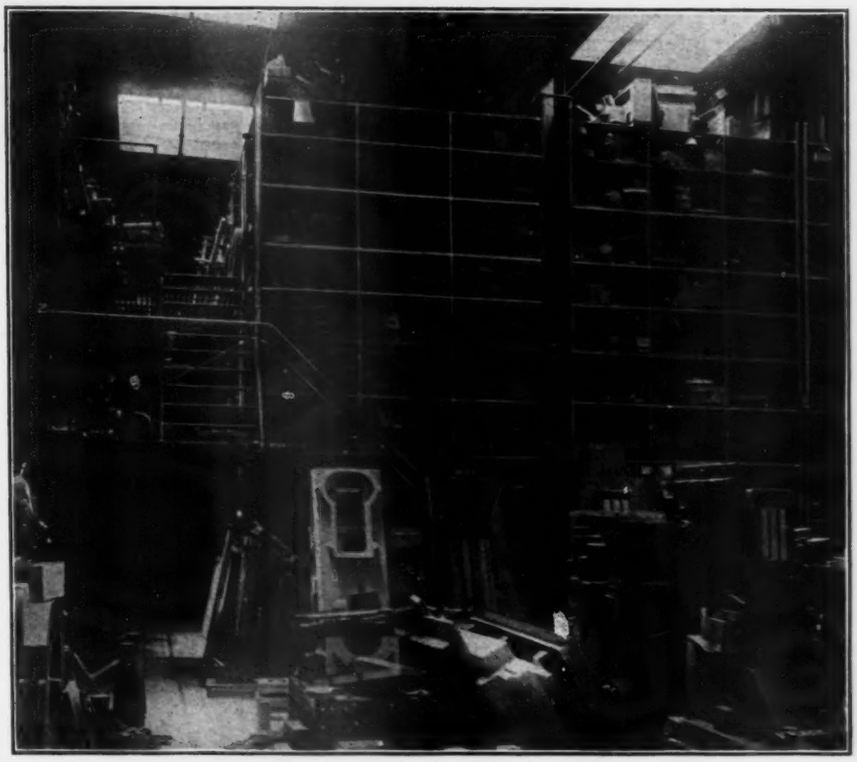


FIG. 7—PATTERN STORAGE, SHOWING STEEL SHELVING

FIG. 8—CASTING STORAGE DEPARTMENT PROVIDED WITH STEEL BINS FOR STORING SMALL CASTINGS

pattern shop and pattern storage to the foundry, and for delivering castings from the foundry to the cleaning, casting storage and shipping departments, an industrial railway system has been installed. The pattern storage room is at the rear of the pattern shop and all patterns are carefully inspected and repaired, if necessary, before being stored. The pattern storage is 60 x 80 feet, of brick construction with a concrete roof and is lighted by skylights in the roof and is without windows in the walls. A section of the pattern storage is shown in Fig. 7, and it will be noted that steel shelving is used throughout. The small patterns are stored in the upper compartments, while larger patterns are placed on the lower shelves. All of the shelves and compartments are numbered and the patterns are correspondingly indicated. Although the shelves are adjustable in height, they are fixed in length and width, being 36 inches wide and 38 inches long. The lower gallery has three and the second gallery four rows of shelves. An iron stairway leads up to the second and third galleries.

All patterns rammed on the jolt-ramming molding machines are mounted on boards built-up of two-inch white pine lumber extending lengthwise of the pattern. Five 3½ x 5-inch battens are fastened crosswise of the boards by lag screws set in from the upper side. The ends of the battens are protected by two-inch steel angles. The lower edges of the boards are protected against wear due to clamping, by a 1¼ x 3½-inch oak strip. Through the center of each

conveyors, located on either side of the industrial track extending through the middle of the foundry, as shown in Fig. 1. The sand is conveyed to the sand-preparing plant, located on the charging floor, as shown in Fig. 3. At *A*, Fig. 4, is shown one of the conveyor enclosures, which delivers the sand to the sand mixing machine shown in Fig. 3. The sand after being riddled, falls into a revolving drum, where it is tempered and then passes through the chute into the receiver of the belt conveyor shown at *B*, Fig. 4. At *E*, Fig. 3, is shown the spout of the core sand conveyor, this sand being mixed by hand. The sand is stored in a building adjoining the foundry and the necessary sand is delivered to the charging floor and to the scraper conveyor by a belt conveyor, *C*, Fig. 4, which operates at right angles to the scraper conveyors. In the sand storage building, a short, horizontal belt conveyor is used to deliver the sand to the conveyor, *C*, Fig. 4. The sand is dumped directly from cars into pits and is conveyed to the foundry by the belt conveyors.

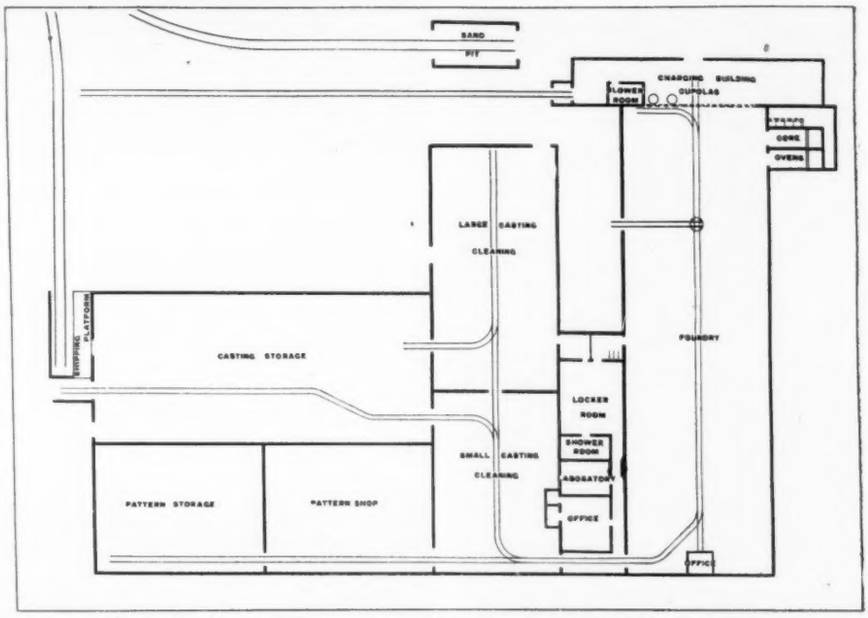


FIG. 10—GROUND PLAN OF THE MODERN FOUNDRY CO.'S PLANT

For conveying patterns from the

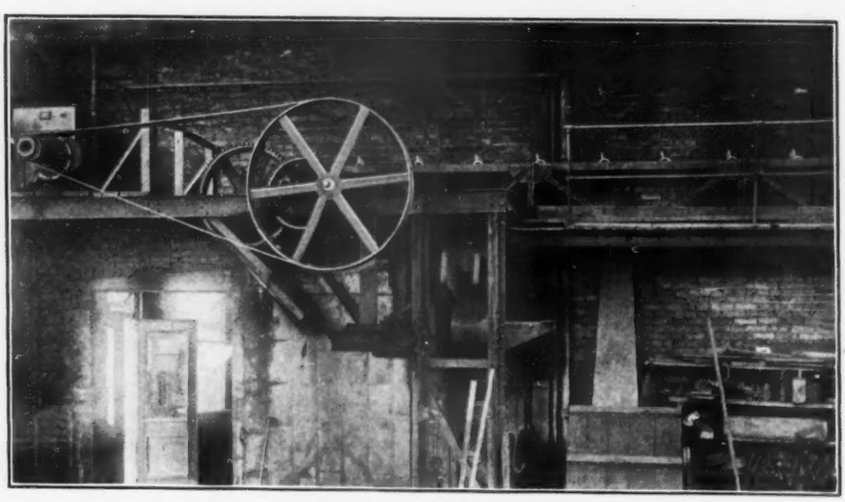


FIG. 9—MOTOR DRIVE FOR ONE OF THE SAND CONVEYORS

board on the upper side a ½ x 3½-inch steel bar is set in flush with the face and is bolted through the battens. Guide pins are attached to either end of the board and four iron plates are set in the four corners of the board to resist the wear of the iron flasks against the board. Milling machines, columns, motor frames and similar work are successfully molded on these jolt-ramming machines.

The casting cleaning department is 200 x 60 feet and parallels the foundry. Castings are delivered to this department from the foundry, over an industrial railway track. The cleaning equipment consists of a sand blast, tumbling barrels, pneumatic chipping hammers, etc. From the cleaning department the castings are delivered to the storage department, from which they are taken to the shipping department when required. The industrial track in the cleaning department is depressed and the floor of the car is on a level with the cleaning room floor. Small castings are stored in steel bins, as shown in Fig. 8. In addition to the industrial track, which delivers the castings from the cleaning department, the casting storage is commanded by a 6,000-pound Pawling & Harnischfeger crane.

In the foundry the piecework system prevails, the molders being engaged in ramming molds throughout the day, and the castings are poured, shaken-out and the sand is tempered by a night gang. The perpetual inventory system has been installed, and in estimating the cost of castings, all items such as coke, pig iron, raw materials and labor are charged against separate orders, while items such as core oil, chaplets, etc., are figured on a tonnage basis.

The Use of Titanium in Cast Iron*

By Charles V. Slocum

WHEN the manufacture of titanium in the form of an alloy was undertaken on a commercial scale in 1907, the results, in primary tests, were considered, for a time, as the basis upon which it would be necessary to place this material on the market. When a number of trials had been made, however, it was found that different results were apparently secured and it then became necessary to modify these original ideas in accordance with these developments and, in fact, as three years is not a long time to learn everything in regard to a new element, this modification is still going on. It was the idea, at first, in using titanium in iron that since comparatively large percentages gave increased strength in tensile and transverse tests, that these larger percentages were essential to the process of securing a titanium reaction in the metal and therefore must be used. Gradually, however, it became evident that minute percentages of titanium were successful in producing many of the benefits of a larger quantity; as, for instance, the use of two-tenths of 1 per cent of alloy, which contains only 0.02 per cent of metallic titanium, is frequently sufficient for the purpose of cleaning the iron of impurities remaining in the metal after the ordinary fluxes have accomplished all that they can in this direction. This cleansing is not one which is possible with limestone or fluorspar, as these fluxes have no effect upon the oxides or nitrides contained in the molten iron.

Titanium, on the other hand, removes both of these objectionable elements, partially in any event, and wholly or practically so when sufficient alloy is used for the purpose. The effect of the small fractions of a per cent in iron is, more practically speaking, to increase the fluidity of the iron and at the same time to make the metal more homogeneous so that the resulting castings are closer-grained, are free from pin holes and gas bubbles or blow holes, the iron has a denser structure and at the same time is easily machined.

Reduces Shrinkage.

The shrinkage is less in the treated iron than in the plain or untreated casting. This is particularly true in hard or chilled iron where heavy castings, such as car wheels, will shrink ⅛ inch or one whole tape number in circumference. Much finer work may, therefore, be done with iron treated with the alloy since the casting will conform more nearly to the original pattern and will have a more uniform shrinkage than the plain iron.

In a letter dated April 5, 1911, the writer was advised by Asa W. Whitney, metallurgist of the Enterprise Foundry & Machine Co., Bristol, Va., that he has made a number of careful trials of titanium in hard or chilling iron. He found that 0.1 to 0.2 per cent of the alloy is usually all that is necessary to make otherwise viscous high chilling mixtures come from the cupola close-grained and pour from the ladle as freely as iron carrying half as much chill and of more open grade. The iron pours well to the last and gives clean, solid castings.

Increases Fluidity.

To foundrymen, the fact that the metal remains hot longer than untreated iron is a matter of much importance for certain classes of work since the increased fluidity means that the iron will settle more slowly in the mold and thus give time for the gases to escape and more time for the iron to fill the smallest outline of the mold without pulling away from the main body of the casting. These features of good foundry practice are frequently overlooked and a high percentage of bad work results. In regard to the benefits to be derived from using larger proportions of the alloy, undue importance has been attributed to increases in transverse and tensile strengths. This may be necessary for certain government work and for a few castings which must resist stresses in service and for these it is necessary to use at least 1 per cent of titanium alloy.

This high percentage not only increases the cost of the product, but for all the practical uses to which most castings are subjected no special increase of strength is required, although an improvement in quality may be absolutely necessary. We have in mind a recent case where the castings in a certain foundry were stronger than necessary, were well made and were satisfactory to the foundry superintendent and to his customers, but when he tried the small quantity of the alloy usually recommended for the purpose of improving the fluidity of the molten metal and the density, machining quality and durability of the castings, he found that the machine shop of one of the great railroads which turned the castings, reported that the treated specimens were closer grained, were more like steel and were more desirable for their purpose. Yet of the four test bars cast the one from

*Presented at the Pittsburg Convention of the American Foundrymen's Association.

the untreated iron was strongest in transverse strength.

On the other hand, a large manufacturer having a 10-ton casting to make and being anxious to avoid failure in so important a job, added 1 per cent of titanium alloy and secured a splendid casting which may have cost him $25 extra for the alloy used, but which made a sure thing of a single part of the machine worth at least $400, without including the machining.

Certain classes of work, of course, do not justify an increase in the cost of manufacture, and yet even in cheap work the use of a pound or two of alloy per 1,000 pounds of iron is a distinct benefit to the metal and costs but 25 to 50 cents per ton of product. Other classes, which will perhaps bear a little more expense, may be increasingly benefited with three or more pounds of alloy per 1,000 pounds of metal.

Titanium in Cylinders.

Iron castings which require great care in molding and which are difficult to make may well be treated with titanium, as such castings cost much money to manufacture and a high percentage of loss works havoc in the showing of profits for a year's business. In cylinders, for instance, and for locomotive and stationary engine castings of various kinds, many manufacturers are now using this cleanser and purifier as a means of not only improving the casting itself, but of reducing the percentage of loss. The feature of greater fluidity cannot be emphasized too strongly. When we seek for increased fluidity through the addition of ordinary fluxes the result is often disastrous, for much fluxing makes the metal boil, and blow holes, pin holes and defective castings generally result together with increased expense in the repairs or even in actual relining of the cupolas.

When titanium alloy is added in the cupola it does not affect the lining unless large percentages are used, and when the larger percentages are necessary it is better to add the alloy in the ladle with the usual precaution of keeping the alloy from the slag so that the full benefit of the use of this cleanser may be secured. There are times when it is not practicable to use the alloy in the ladle and other times when it should be used in this way.

To illustrate, in adding 1 per cent of alloy for purposes already mentioned it should preferably be done in the ladle and if practicable in the receiving ladle, but this can only be done when it is possible to keep the iron free from slag by skimming or by some other means. Titanium attacks the slag and should, therefore, always be used to cleanse the iron from impurities remaining in the metal after the melting process has been completed, and never, by any chance should it be allowed to reach the slag already on the surface of the iron or about to be removed from its surface.

Titanium in Low-Grade Iron Mixtures.

In a recent trial of titanium alloy in a cupola with a mixture of burnt iron, stove plate, etc., in a large foundry in the Pittsburg district, the rather large percentage of one-half of 1 per cent of alloy was used with one-half of 1 per cent of ferro-manganese of the usual 80 per cent grade. This trial demonstrated the interesting fact that the poorest mixture may be brought to good, normal iron by this method. The average of all the test bars, of which there were ten, was 3,100 pounds breaking strain and an average deflection of 0.146 inch. Under ordinary conditions, with the addition of the manganese alone, the strength would scarcely have reached 2,000 pounds per square inch. It should be remembered that burnt iron is usually high in sulphur and the iron in these castings contained 0.151 and 0.147 per cent of sulphur, respectively, by two different analyses. Such a remarkable strength from so poor an iron is unobtainable at anything like the small cost by any other process since the expense of making the metal homogeneous was about $1.50 per ton of castings. The iron, before treatment, was probably worth $10 per ton. The analyses of the treated iron by two separate determinations was as follows:

Silicon, per ct.	Combined carbon, per ct.	Graphitic carbon, per ct.	Phosphorus, per ct.	Sulphur, per ct.	Manganese, per ct.
1.30	0.70	2.50	0.504	0.151	0.71
1.30	0.74	2.42	0.455	0.147	0.79

High sulphur iron may be made strong and available for practically all purposes by an expenditure of $1.50 or less per ton of metal melted.

Other Beneficial Results.

In the works of a large foundry in Columbus, Ohio, a cheap mixture is used for certain purposes which analyses as follows: Silicon, 1.60 per cent; sulphur, 0.11 per cent; phosphorus, 0.55 per cent, and manganese, 0.50 per cent. One-fourth of 1 per cent of titanium alloy was added in the cupola and the foundry foreman reported immediate benefit in the fluidity of the metal and in the distinct improvement to the castings. This rejuvenation of the iron involved an extra cost of 62½ cents per net ton of metal treated and was more than repaid in the reduction in bad work without regard to the benefit to the iron. Castings from this iron with fine grain and good metal were made, which were only 5-16 x ¼-inch section.

In using any alloy do not govern the quantity or the method entirely by the unsupported statements of others, but be governed largely by the particular features and practices of the foundry in which the trial is to be made. For instance, a large manufacturer reported a failure of titanium alloy to improve iron when used in a cupola which was not slagged and which, therefore, kept the titanium in almost constant contact with the very impurities which should have been kept away from it.

Another questionable procedure is to have a few of the castings looked after carefully by some capable man like the foreman or even the superintendent and then to have the other titanium additions of the same kind of iron and from which the same results are expected looked after by some laborer.

The don'ts are almost more necessary in the use of this alloy than important rules of guidance. We can undertake to put a great deal of pressure upon the foreman, but unless he has sufficient foresight to realize, for instance, that silicon, although used as a softener, is also, at times, a great weakener of good iron and, therefore, should be used as sparingly as possible with titanium (which does all the softening necessary without weakening the iron) it would be useless to instruct him as to the merits of an alloy.

Cupola Practice*

By R. H. Palmer

IN CONSIDERING cupola practice, the laying of the fire brick lining is of first importance. In many foundries this receives little attention and the bricks are laid too far apart, thereby requiring more grouting than necessary. This soon burns out, leaving the edges and corners of the bricks exposed. The closer the bricks can be laid the longer the lining will last. A double lining is to be preferred to one consisting of only one row of bricks. Mica schist is used in some foundries in place of fire brick and good results are obtained. The schist is in the form of broken stones and

*Abstract of a paper presented at the Pittsburg convention of the American Foundrymen's Association.

is laid in mortar made of ground schist. Lining the cupola above the melting zone with cast iron bricks is also meeting with good results in some foundries. The cupola lining should be thoroughly dry before lighting the bed. While one row of tuyeres is preferred by many foundrymen, increased speed of melting is obtained by the use of two rows of tuyeres. The introduction of a sufficient volume of air, at the right pressure, through a properly arranged set of tuyeres, which will properly distribute the air so that perfect combustion of the fuel may be obtained, is of the utmost importance for successful and economical melting.

Blast Pressure.

It has been my experience that the lining will not last as long with two rows of tuyeres as with one, especially if too high a blast pressure is used. I am not in favor of small tuyeres and high blast pressures, but prefer a large tuyere area and low blast pressure. Cooling the lining with a stream of water should be avoided, as it soon destroys the blasts. The chipping and daubing of the cupola lining is another essential feature and frequently the face of the bricks are cut away. This likewise should be avoided. When daubing parts where the lining is thin, split brick or pieces of broken brick should be used. The tuyeres and wind box should always be kept clean. The overflowing of the slag and metal into the wind box frequently causes much trouble. To carry off the iron in the wind box the bottom should be lined with clay and numerous holes should be provided in the bottom of the wind box extending through the clay bottom. Wooden plugs are driven into these holes and when the iron overflows into the wind box it will soon burn out the wooden plugs and will flow out of the blast box without causing any further inconvenience.

When repairing the cupola lining the slag hole is formed if the slag is to be tapped. This should be located below the bottom line of the lower tuyeres and at a point where the blast will not be directed against the slag hole. It should also be located a sufficient distance below the tuyeres to prevent the slag from rising and flowing into the tuyeres. The slag hole should be closed with a mixture of molding sand and molasses water. Oil burners and gas are now largely used for lighting the cupola and great economies have thereby been effected.

The melting zone of the cupola can easily be located the morning following the heat by examining the condition of the lining, and later, by experimenting with various amounts of coke on the bed, the foundryman can determine to what height the bed should be raised to obtain the best melting conditions. While too high a bed charge is a waste of fuel, a bed that is too low permits the air from the upper tuyeres to enter too close to the bed charge of iron and unless the bed is raised by subsequent charges, the quality of the iron will be affected throughout the entire heat. The breast should be 2½ inches in thickness around the tap hole for a cupola lined to 30 inches and 3 inches in thickness for one lined to 72 inches. Care also should be exercised in charging to level the charges of coke and iron, and the charging of large pieces of scrap that will cause a hang should be avoided. When using steel in the mixture this should be charged upon the bed at some distance from the tap hole. If soft iron is desired the pig iron is charged first, followed by the scrap.

Slagging.

When charging a 72-inch cupola, it is our practice to charge a bed containing 2,800 pounds of coke, on which is placed 5,000 pounds of iron, 140 pounds of coke and 5,000 pounds of iron. If extremely large pieces of scrap are used in the later charges, 490 pounds of coke are used on a 5,000-pound charge of iron. The coke we are using has a good cellular structure and contains 1.15 per cent of sulphur. While the sulphur content is high, nevertheless this coke sustains the iron charges and gives satisfactory results. Beginning with the fifth charge, limestone is added to slag the cupola and the slag is tapped usually after melting 15,000 to 20,000 pounds of iron. We use 40 pounds of limestone per ton of iron melted. If too much limestone is charged it will attack the face of the fire brick lining, forming with it a fusible slag. If an insufficient amount of limestone is used the slag will not flow easily, will be sluggish and will freeze up the slag hole. We also use fluorspar, which does not attack the lining. Oyster shells are used by some foundrymen, but we have found that they are objectionable on account of the phosphorus they contain.

Special Mixtures.

When melting the last charge the blast pressure should be reduced, unless particularly hot iron is desired. From experience, it is evident that more cutting of the lining occurs during the latter part of a heat when the blast pressure is high than with low pressures. The iron reclaimed from the drop is a source of considerable trouble in some foundries, where all the iron is drained from the furnace and the drop is wheeled to the dump the following morning. This is poor practice, as the iron from the drop should be reclaimed and should be charged back into the cupola, being distributed throughout the various charges. The height of tuyeres above the sand bottom is a question that has been widely discussed by foundrymen and this should be governed by the class of castings produced and the facilities for handling the iron quickly. In foundries producing light castings, the tuyeres can be set lower than in shops producing heavy castings. In foundries producing light work the cupolas are seldom slagged, and where slagging is practiced the tuyeres must naturally be high. Low tuyeres give low melting ratios and less fuel is required on the bed charge. While much can be said in favor of small charges, nevertheless, when different grades of iron are tapped out of the cupola in one heat, the practice of charging in small quantities cannot, satisfactorily, be followed. In a foundry making engine castings, special mixtures are frequently required and the iron for this mixture is usually charged first and on this a larger charge of coke is placed than is required. In this way the first iron down will consist entirely of the special mixture desired. As the various mixtures from a furnace melted in one heat will usually overlap, the charges can be so arranged to tap out more than the amount of the first mixture, if soft iron follows hard and the soft iron then be tapped out of the cupola immediately after the hard. On the other hand, the charge for the hard iron mixture can be in excess of what is required and this excess can be used for other work. Low melting ratios can usually be obtained when the pig iron and scrap are broken small, but the cost of breaking is also to be considered.

The Shanafelt Mfg. Co., Canton, O., manufacturer of pattern shop and foundry supplies, has closed negotiations with Hammacher, Schlemmer & Co. Fourth avenue and Thirteenth street, New York City, whereby this concern will act in the capacity of eastern agents and will carry a stock of the entire line of products manufactured by the Shanafelt company. A branch office has also been established in the Western Union building, Chicago, under the management of Willis C. Squire.

THE FOUNDRY

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Trade Outlook

Foundry trade conditions have shown a slight improvement during the month and the indications are that the demand for castings will not be materially affected by the midsummer lull. The most encouraging feature of the situation is the buying of the railroads and while no large tonnages have been placed, orders have been received from widely scattered sections with insistant demands for prompt deliveries. The usual large stocks of castings carried by the railroads have been practically depleted and the orders now being placed cover only current requirements. The crop prospects also foreshadow a distinct improvement in trade conditions and the implement manufacturers, who cancelled casting contracts several months ago, are resuming operations and are preparing for a heavy fall demand. In the steel trade the recent reduction in prices is already having a wholesome effect and several large works that were shut down earlier in the year are again in operation. The pig iron situation is somewhat peculiar as the stocks that are usually found in the yards of consumers during periods of depression are now largely held by the producers. The slightly increased demand for castings has developed more active pig iron buying, but until the stocks in furnace yards are moved, no advance in prices is anticipated. The non-ferrous metal market is also displaying increased activity and while quotations have not moved upward, sales have grown in volume. In the leading centers No. 2 foundry iron is quoted as follows: Pittsburg, $14.40; southern Ohio, Cincinnati, $14.45; southern, Birmingham, third quarter delivery, $10; New York, tidewater, $14.50 to $15; Chicago, $15. Lake Superior charcoal continues to be held at $17, Chicago, and basic is quoted at $14.15 Pittsburg and $14.50 Philadelphia. Copper in 25-ton lots of 2,240 pounds each, is quoted at 12.75 cents for Lake, 12.62½ cents for electrolytic and 12.25 cents for casting at New York. Tin in not less than 5-ton lots is quoted at 44.5 cents New York and lead in car load lots is held at 4.45 cents New York. Antimony, New York delivery, is quoted as follows: Cookson's, 9 cents; Hallett's 7.87 to 8.25 cents and other brands at 7.20 to 7.30 cents. Other metal quotations follow: Aluminum, No. 1 pure ingot, 20 to 22 cents; nickel in large lots, 40 to 45 cents; magnesium, 100-pound lots, $1.50 per pound, and bismuth, $1.80 to $2.00 per pound.

Province of the Foundry Instructor

Evolution of the foundry industry is a hackneyed term applied to every progressive step in casting practice and the latest advance that marks either evolution or revolution, involves the employment of a foundry instructor whose duty it is to show the men short cuts and proper methods of doing work. It might further be added that he aids in every way toward getting a maximum production with least effort and it is needless to state also, with the greatest possible economy. In a large western foundry four such supervisors are employed and in addition to their other duties, they route the work in their respective departments so that each molder will be assigned the work for which he is best adapted. In a measure the instructor is a sub-foreman, but with greater responsibilities. It might also be interesting to inquire whether this new shop executive has not been introduced as the forerunner of *scientific management* in the foundry and if this is true, it is a step in the right direction. Yet the foundry instructor is by no means a novelty, as he is a part of the system of pricing molding machine work in stove plate shops. At a recent annual gathering of those engaged in the metal trades, a suggestion was made that instructors be employed to impart a knowledge of molding machine practice to foundrymen. Whether prompted by the labor problem or defective castings, could not be gleaned from the discussion, but if the latter, many foundrymen will agree that instructors in machine shop practice might at times prove equally beneficial and their training and experience should be so directed that they will be able to judge between sound and defective castings. While on the subject of instructors, one experienced in foundry practice might prove a valuable addition in the drafting room and even the pattern shop might be benefited by his knowledge. The province of the foundry instructor is by no means limited to the casting shop and his occasional advice to the employes of some of the other departments would prove a valuable aid in smoothing out the numerous difficulties that beset foundry operations.

Steel Foundry Practice

To the Editor:—

Referring to the report of the discussion of steel foundry practice at the Pittsburg convention of the American Foundrymen's Association, published in the June issue of THE FOUNDRY, I am quoted as follows: "That

although the thermit would increase the silicon, it is not possible to avoid other deteriorating changes in the composition of the last few hundred pounds of metal poured." The point raised by Prof. Stoughton related to the addition of thermit and silicon and whether it offered a satisfactory solution of the maintenance of the high quality of steel in the last part of the basic heat. My reply was that the addition of these two substances does not take care of this entirely. The point I wish to call attention to is that the simple addition of thermit alone will not increase the silicon content. R. A. BULL.

Personal

Walter S. Bickley has been elected president of the Penn Steel Castings & Machine Co., Chester, Pa., to succeed his father, the late Mortimer H. Bickley.

H. A. Hunt has been appointed eastern sales agent of the Edgar Allen American Manganese Steel Co., succeeding V. W. Mason Jr., resigned. Mr. Hunt will have his headquarters at New Castle, Del.

The Brylgon Steel Casting Co., New Castle, Del., announces the appointment of Frederick Baldt Sr., as manager of this concern. Mr. Baldt is well-known and has an extensive experience in the steel casting business.

Walter B. Snow, publicity engineer, 170 Summer street, Boston, has recently added to his staff, John S. Nicholl, late of the New York Edison Co. and formerly acting manager for F. W. Horne, importer of American machinery, Yokohama, Japan.

R. O. Lovell, who has represented the Oliver Machinery Co., Grand Rapids, Mich., during the past eight years, has tendered his resignation, effective July 1, to take charge of the Chicago office of the Werner & Pfleiderer Co., Saginaw, Mich., manufacturers of chemical machinery.

C. E. Knoeppel is now associated with Suffern & Son, certified public accountants, 165 Broadway, New York City. Mr. Knoeppel's work will largely consist of the introduction of efficiency methods in industrial enterprises with specific reference to the foundry industry. During the past two years he was affiliated with Harrington Emerson.

Obituary

James W. Kissick, foreman of the foundry department of the Columbus Iron Works, Columbus, Ga., for many years, died at his home in that city, May 11. Mr. Kissick was born in Philadelphia, May 12, 1847, and is survived by a widow and six children.

Book Reviews

Foundry Irons.—By Edward Kirk; 6 x 9 inches, 276 pages, illustrated. Published by Henry Carey Baird & Co. and furnished by THE FOUNDRY for $3, postpaid.

This work has been prepared to meet an insistant demand for practical information on foundry irons and their manipulation in the production of the various classes of castings. The author presents, in a condensed form, only such matter as is of a practical value to the founder and has eliminated, as far as possible, theories that have not been established as principles and all laboratory experimental work that has not been fully demonstrated to be useful in actual foundry practice.

The work contains useful data on the manipulation of foundry irons as actually practiced in foundries by both the old and the new methods. In this way is placed before the founder, foundry foreman, molder and melter, such a variety of methods that he cannot fail to obtain good results under any and all of the various conditions met with in the manipulation of these irons. Semi-steel is extensively treated from knowledge gained by the author in producing this metal and from information obtained from practical foundrymen engaged in this practice.

The history and sources of iron, its manufacture, as well as the fuel used in smelting, is briefly discussed and coke for foundry use is comprehensively treated and includes both the by-product and beehive varieties. A chapter on the loss and gain of iron in melting is interesting, as it contains the loss percentages of various grades of scrap melted in the cupola. Foundry chemistry and elements and metalloids are also discussed from the foundryman's standpoint. The fracture grading of pig and scrap iron will prove helpful to the foundryman, particularly the latter, although pig iron today is rarely, if ever, judged by fracture in this country. The chapter on mixing irons will prove exceedingly valuable, as it contains formulas for practically all classes of castings. Other subjects discussed include casting by direct process, grading iron by analysis, chemical standards for iron castings, testing cast iron and malleable iron, including the making of mixtures and methods of annealing. Twenty pages are devoted to foundry notes and contain practical hints on annealing, pickling, and tinning cast iron, as well as a discussion of the defects of cast iron and suggestions for overcoming these difficulties.

The work is essentially practical and will prove a handy text book for foundrymen engaged in the manufacture of gray iron or malleable castings.

A Study of the Blast Furnace, by the Harbison-Walker Refractories Co., Pittsburg; 163 6¾ x 4-inch pages, illustrated.

"A Study of the Blast Furnace" is the second of a series of works on iron and steel manufacture, issued by the Harbison-Walker Refractories Co., Pittsburg, which, in every way, measures up to the high standard set by the first volume of this series, entitled "A Study of the Open-Hearth." The work is written in a simple, direct style, and while it purports to be merely a digest of widely scattered information relating to blast furnace operation, it reflects great credit on the compiler, who used excellent judgment in the selection of information. The early chapters describe the blast furnace plant, including the stack and its equipment, as well as the hot blast stoves and such disposal equipment as pig beds, chills, casting machine, etc. The materials used in iron manufacture are also discussed at length and 11 pages are devoted to the treatment of ores. Fluxes and fuels comprise another chapter and the burdening of the furnace, discussed at length, will appeal to every blast furnace operator. A problem in furnace burdening is also solved and all of the necessary computations are given. The chapter on the operation of the furnace includes discussion of such subjects as blowing in, charging, operation of furnace, banking the furnace, blowing out, operation of stoves, and such troubles as destruction of the lining, break-outs, loss of tuyeres and cooler plates, pillaring, scaffolding, wedging, chilling, etc., are gone into in great detail. The work concludes with a general discussion of furnace reactions. A map, in colors, showing the blast furnace districts and iron ore deposits of the United States is also included. This volume is handsomely printed, well illustrated, and is bound in leather.

At a recent meeting of the Lancashire (Eng.) branch of the British Foundrymen's Association, officers for the ensuing year were elected as follows: President, F. Penlington; vice presidents, J. Simkiss, T. W. Markland, W. H. Sherburn and W. Wright, and secretary, H. Sherburn; executive committee: R. W. Kenyon, A. Harrison, H. S. Skelton, F. Andrew, F. W. Robinson and W. McVie.

FOUNDRY and PATTERN SHOP EQUIPMENT

Jar-ramming, roll-over molding machine for sanitary ware--- Jolt-ramming coremaking machine --- Fuel oil crucible furnace --- Hydro-carbon burner --- Portable crucible furnace

IN THE molding of sanitary ware, such as sinks, lavatories and other light castings, many attempts have been made to eliminate hand ramming, which is necessary when these sections are molded on stripping plate and similar types of molding machines. The Herman Pneumatic Machine Co., Zelienople, Pa., conducted many experiments in the molding of these sections on jar-ramming machines, and it was found that to successfully solve the molding problem on machines of this type, would involve an entirely new method of pattern construction, as well as flask equipment. The process devised involves the use of a jar-ramming, roll-over molding machine, Figs. 1 and 2, showing the cope and drag lavatory pattern respectively, mounted on the roll-over jar-ramming machine. The flasks are rigidly constructed and consist of steel channels bolted together. The pattern is embedded in a pattern frame attached to the roll-over plate, which rests on the table plate.

When making a mold, the flask is filled with sand and by admitting air to the jarring machine cylinder, the table plate is raised and dropped on a resilient surface in the base of the machine. After jar-ramming, the surplus sand is struck-off, but no bottom board is used, as both cope and drag flasks are barred. The flask is clamped to the pattern frame and when air is admitted to the side lifting cylinders, the pistons that engage the roll-over plate move upward until a sufficient height is reached to permit rolling over the flask. The plate is held in suspension by the side lifting cylinders, while a buggy about the size of the table plate, is inserted underneath the roll-over plate. When the air is discharged from the side lifting cylinders, the flask and roll-over plate are deposited on the buggy. This buggy is operated by a horizontal pneumatic cylinder and can be moved in either direction. When the clamps are removed from the flask, air is again admitted to the side cylinders and the pattern is drawn from the mold. When the air is released from the horizontal cylinder, the buggy on which the mold is resting is withdrawn from the table plate and the mold is ready to be conveyed to the floor. The suspended pattern is next rolled over, and discharging the air from the side lifting cylinders permits the roll-over plate to descend to its former position for the ramming of another mold. On this machine any pattern with a depth of over four inches may be matched on the roll-over plate and molded as previously described.

This machine can also be arranged for stripping plate work by eliminating the roll-over plate. In this case the pattern is attached to the table plate and the side lifting cylinders engage the stripping plate and strip the mold from the pattern, the movement being similar to that employed when the roll-over plate is lifted by the side cylinders. The mold, however, will be rammed by the jar-ramming process. The machines with the roll-over or stripping plate attachments are built in the following table plate sizes: 24 x 30 inches, 30 x 45 inches, 40 x 50 inches, 50 x 50 inches, 60 x 60 inches and 60 x 72 inches. In one sanitary ware plant, approximately 23,000 18 x 24-inch roll rim sinks have been made on these machines and the

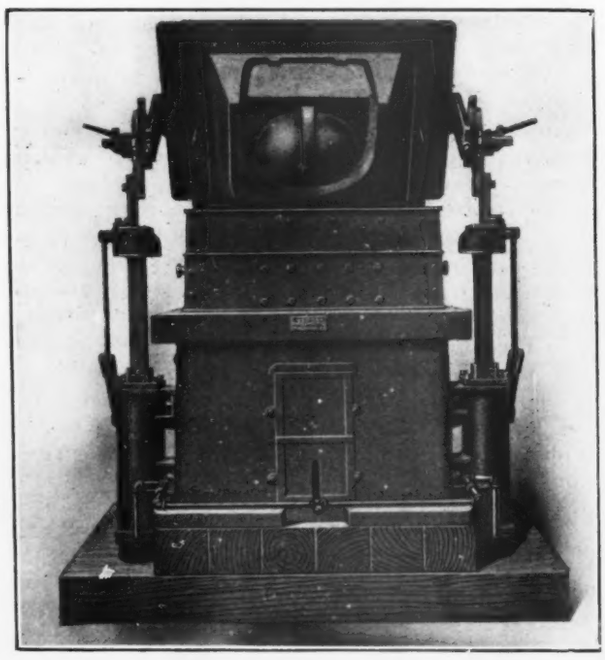


FIG. 1—JAR-RAMMING, ROLL-OVER MOLDING MACHINE, EQUIPPED WITH COPE HALF OF LAVATORY PATTERN

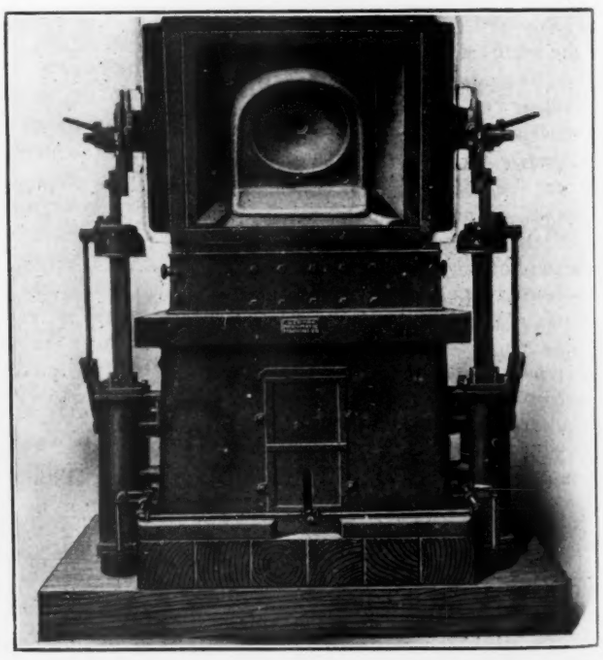
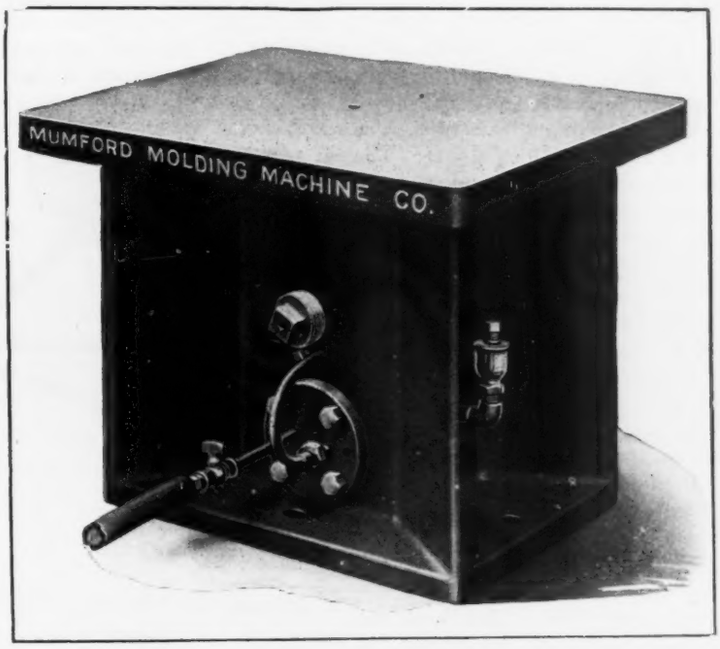


FIG. 2—JAR-RAMMING, ROLL-OVER MOLDING MACHINE, EQUIPPED WITH DRAG HALF OF LAVATORY PATTERN

castings have been found to be more uniform in weight than when molded by hand.

Jolt-ramming Core-making Machine

A core bench jolt-ramming machine, built by the Mumford Molding Machine Co., Plainfield, N. J., is shown in the accompanying illustration. This machine can be placed on a concrete pier, iron post or even on a wood foundation, and is especially adapted for ramming irregular cores. The machine is actuated by a knee valve under the bench, thereby permitting the operator to use both hands to manipulate the material and the core boxes. While the rate of



JOLT-RAMMING, COREMAKING MACHINE

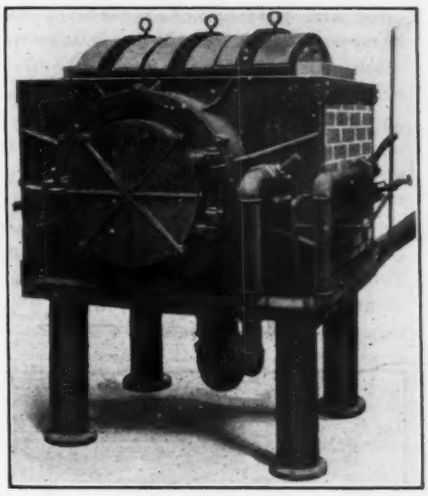
capacity of the machine is 300 pounds, with 80 pounds air pressure, it can be used to advantage on small slender cores, which, together with the boxes, weigh only a few pounds. The valve consists of a plug of case-hardened machinery steel, having a $\frac{3}{16}$-inch vertical stroke. The size of the table is 15 x 20 inches and the diameter of the plunger is 3 inches. The finished shipping weight of the machine is only 325 pounds.

Fuel Oil Crucible Furnace

Alfred Fisher, Chicago, has recently perfected a new type of oil burning, crucible furnace, which is illustrated herewith. This furnace is capable of holding six No. 60 crucibles and it is claimed it will melt a heat of scrap steel, boiler punchings, rods, castings, etc., in three hours. Four burners are used, one on each side, adjusted so that the flame enters tangentially to the circular door frame, which produces a complete ring of flame inside the furnace. The furnace has no flues or chimneys and is designed to burn fuel oil. The blast is furnished by a positive pressure blower and the oil is fed by gravity. The flame is so adjusted that it does not strike the crucibles. The furnace is mounted on four heavy cast iron columns and the sides are built of heavy ribbed cast iron plates, as shown in the illustration. A thick fire brick lining is, of course, provided. The top of the furnace is covered by three bungs similar to those used on an air furnace.

Hydro-Carbon Burner

A hydro-carbon burner, manufactured by W. N. Best, 11 Broadway, New York City, which is adapted for use on malleable iron air furnaces using oil for fuel, is shown in the accompanying illustration. It will be noted that the oil orifice is underneath the atomizer slot and as the fuel passes upwardly out of the burner, it contacts with the atomizer and passes out horizontally. This peculiar construction causes the fuel to be so thoroughly atomized that a mist or vapor is formed and prevents the burner from carbonizing. If sand, scale, red lead or other foreign substance should find its way into the pipes, the lip of the burner can be raised by removing the set screw in the bridle and opening the atomizer valve. The foreign substance can then be blown out without necessitating the removal of the burner from its position in the furnace. The burners can be adjusted for a fan-shape flame, 9 feet wide, or for a long, narrow flame, only 12 inches wide. The



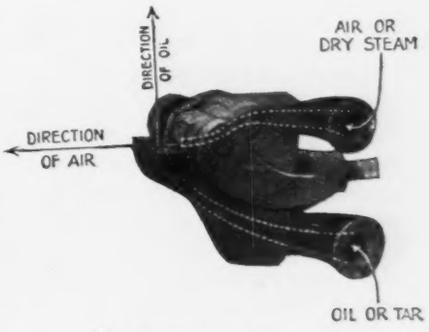
FUEL OIL CRUCIBLE FURNACE

burners are tested and set to give the exact width of flame required for the furnace in which it is to be installed.

Power for Tumbling Barrels

In a recent investigation by Lockwood, Greene & Co., Boston, engineers and architects for industrial plants, there was occasion to determine the actual power required for the tumbling barrels and for the sand sifters in an iron foundry. This investigation was conducted in connection with determining the feasibility of replacing three separate power plants with one central plant in a large manufacturing concern.

The tumbling barrels were arranged two on a shaft, the size of the barrels being 36 and 48 inches in diameter.

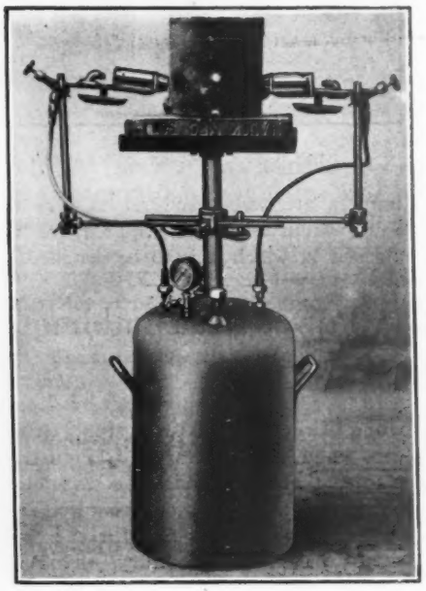


HYDRA-CARBON BURNER

As a rule, the load was only one barrel, but about 25 per cent of the time both were operated. It was found that the average power demand was 4.3 horsepower, while the maximum with both barrels loaded was 5.8 horsepower. The shafting with the

barrels running light required 2.75 horsepower; with the smaller barrel filled and the larger one empty the total power necessary was 4.15 horsepower, while with the larger barrel filled and the smaller one empty 4.45 horsepower was required. It was decided that a 5-horsepower squirrel cage induction type motor would be ample for driving these two barrels.

Regarding the sand sifter, this had a driving pulley 12 inches in diameter with 6-inch face and a speed of 630 revolutions per minute. The power consumption of the sifter running light was 0.38 horsepower. The momentary maximum load with both sides of the sifter full was 1.3 horsepower. A 3-horsepower motor was recommended as ample for this service.



PORTABLE FORGE ARRANGED FOR MELTING BRASS, ALUMINUM AND OTHER METALS IN CRUCIBLES

A Portable Crucible Furnace

In the accompanying illustration is shown a kerosene forge, built by the Hauck Mfg. Co., Brooklyn, N. Y., adapted for use as a crucible melting furnace. This forge is so arranged that it can be utilized also in the machine shop for brazing, annealing, tempering, forging, preheating, heating soldering irons, etc. The forge can be quickly converted into an oil furnace and the burners can be used for skin-drying molds, lighting cupolas, etc. The forge or brazing table consists of a 12-gallon seamless steel tank, inside of which is located a hand pump. Two powerful burners, connected with a hose, are mounted on brackets so that the positions of the burners can be quickly changed. The table extending from the top of the tank is lined with refractory tiles. When adapted for melting brass, aluminum and other metals, the crucible is set into the circular tile-lined pot shown on the table in the accompanying illustration.

An Oscillating Sand Sifter

In the accompanying illustration is shown a portable oscillating sand sifter which is operated by a compressed air motor and is mounted on a steel tripod with a wheel on one leg to facilitate the movement of the sifter from floor to floor in the foundry. The piston rod of the compressed air motor connects directly with the sieve holder or clamp and the sieve oscillates on a center post, as shown in the accompanying illustration. The piston rod has a five-inch stroke. The motor is completely enclosed, thereby preventing the sand from working into the operating parts. A box at the front of the motor, packed with waste, serves to clean the piston rod from adhering sand. The sieve is supported in a rigidly constructed frame to which it is clamped by a spring band which releases the sieve as soon as it is loosened. The pipe connection for compressed air is underneath the base of the motor. The sand is sifted by a comparatively slow movement of the sieve and as the sand is not shifted from one side of the sieve to the other, vibration is practically eliminated. This sand sifter is built by the Gregg Mfg. Co., Cleveland.

Trade Notes

The Crescent Machine Co., Leetonia, O., manufacturer of wood working and pattern shop machinery, is sending to the trade a celluloid base ball scorer.

The Gobeille Pattern Co., Niagara Falls, N. Y., has established a branch shop at Niagara Falls, Ont. The work at this plant will receive Mr. Gobeille's personal attention.

The Steel-eene Co., Chicago, is manufacturing a metallic cement, known by the trade name of "Steel-eene," which is furnished to foundrymen in cans containing 25, 50 and 100 pounds, respectively.

The H. W. Johns-Manville Co., New York City, is manufacturing a solder in paste form, which can be used for soldering wire and other pieces of metal. The surface of the parts to be soldered is scraped and after the soldering paste is applied, it is heated with a lighted match, candle or torch and immediately fuses.

The Thos. W. Pangborn Co. announces the removal of its executive, sales, accounting and purchasing divisions, which for some years have been located at 90 West street, New York City, to its Jersey City plant, where the manufacturing and engineering divisions, as well as the show rooms, are located. The company's plant in Jersey City is at Hudson and Morris streets.

The Sprague Electric Co., New York, manufacturer of electrical equipment, has been merged with the General Electric Co., Schenectady, N. Y., and its business will be conducted under the name of the Sprague Electric Works of the General Electric Co. D. C. Durland will continue in charge of this concern in the capacity of general manager and the principal offices will be continued at 527 West Thirty-fourth street, New York City.

OSCILLATING SAND SIFTER DRIVEN BY PNEUMATIC MOTOR

The sales organization of the Sand Mixing Machine Co., 220 Broadway, New York City, has been further strengthened by the appointment of Wm. A. Heartt, formerly associated with the McMyler-Interstate Co. Mr. Heartt will have charge of the Indiana, Illinois, Michigan and Wisconsin territory, and Hutton H. Haley, formerly western representative of the J. D. Smith Foundry Supply Co., will represent the Sand Mixing Machine Co. in eastern Ohio, Pennsylvania and western New York. Orders for sand mixers have recently been received from the Cribben & Sexton Co., Chicago, the Charter Oak Stove & Range Co., St. Louis; J. H. McLain Co., Canton, O., and the United States Sanitary Mfg. Co., Monaca, Pa.

Acid-Resisting Bronze

Question:—We would like to obtain a formula for an acid-resisting yellow brass, suitable for making screen plates, used in sulphite mills.

Answer:—An acid-resisting yellow brass has never been discovered, alloys of copper and zinc being peculiarly susceptible to corrosion. Therefore, it is the usual practice in making screen plates to employ an alloy that contains considerable lead. This is done for two reasons. Lead being an acid-resisting metal is supposed to impart similar properties to the metals with which it is alloyed, and because of the large amount of machine work that has to be done on these castings it is important that the metal be easily machineable. Probably the most satisfactory alloy that could be used from an acid-resisting standpoint, would be a good bronze, made of copper and tin, containing no zinc and the minimum amount of lead that would permit the metal to be freely cut. Cost considerations, however, are often all-important and preclude the use of such expensive material; therefore, it is not unusual for these plates to be made entirely of scrap brass leaded to the limit. The composition of two alloys suitable for red brass screen plates is as follows: Copper, 86 pounds; lead, 9 pounds; tin, 3 pounds, and zinc, 2 pounds; and copper, 85 pounds; lead, 8 pounds; zinc, 4 pounds, and tin, 3 pounds. For a yellow brass try the following: Copper, 76¾ pounds; manganese copper, ¼ pound; zinc, 15 pounds; lead, 5 pounds, and tin, 3 pounds.

Trade Publications

CLAMPS.—The Batavia Clamp Co., Batavia, N. Y., has issued a 24-page catalog, illustrating and describing its extensive line of clamps, hand screws, jacks, etc.

TROLLEYS.—Maris Bros., Philadelphia, have issued a booklet which contains illustrations and descriptions of their line of I-beam trolleys, as well as a price list covering the various capacities of these conveying devices.

PLATINUM WARE.—J. Bishop & Co., refiners of platinum, gold and silver, Philadelphia, illustrate and describe platinum ware for laboratory use, in a 48-page catalog. Tables of weights of platinum ware, sheet and foil, are also included.

MANGANESE STEEL.—In an eight-page booklet issued by the Edgar Allen American Manganese Steel Co., Chicago, the application of manganese steel to the ceramic industries is described in a reprint of a paper read by G. W. Kneisly of this concern, before the National Brick Manufacturers Association.

FOUNDRY TRAMRAIL.—The Moyer overhead tramrail system, adapted for conveying cores, hot metal, raw materials, finished castings, etc., in foundries, is illustrated and described in an eight-page bulletin issued by the Rockwell Furnace Co., New York City. Many installations of this system in various foundries throughout the country are shown.

JAR-RAMMING MOLDING MACHINES.—The Lawlor Improved Jarring Molding Machine Co., 905 Century building, Pittsburg, in an eight-page circular, describes its improved jar-ramming molding machines and a portable combined jar-ramming and squeezing machine. The description is a reprint from an article published in THE FOUNDRY, May, 1911.

MONEL METAL.—In a 32-page booklet issued by the Bayonne Casting Co., Bayonne, N. J., the properties and uses of Monel metal are discussed. Many tests are included, showing the strength of Monel metal castings and brass and bronze alloys containing Monel metal. Monel metal is now made in the form of rods, sheets and wire, and is also used extensively in the production of forgings.

AIR COMPRESSORS.—The Thos. H. Dallet Co., Philadelphia, has issued three bulletins illustrating and describing its line of belt and steam-driven air compressors. The steam-driven machines are recommended for work where the demand for air and steam furnished does not exceed 125 pounds per square inch, and the belt-driven machine is suitable for pressures within the usual limits of single stage compressors.

PATTERNS.—In a handsomely-illustrated 20-page booklet, the Cleveland Castings Pattern Co., Cleveland, directs attention to its facilities for the manufacture of patterns for stove castings. In addition to operating a pattern shop, this concern has a designing department and specializes, not only in wood, but metal patterns as well. Special attention is also given to the mounting of patterns for molding machine work.

ELECTRIC PYROMETERS.—In a 16-page catalog, issued by the Wilson-Maculen Co., New York City, its line of electric pyrometers is illustrated and described. This concern is also sending to the trade a hanger which contains a table for the conversion of Centigrade to Fahrenheit and vice versa, as well as melting points of the elements. This hanger will prove of value in the melting departments of iron, steel, brass and malleable foundries.

ALBANY SAND.—The Whitehead Bros. Co., 537-539 West Twenty-seventh street, New York, and Providence, R. I., has issued a booklet describing Albany molding sand, which is particularly adapted for stove plate work. Superiority is claimed for it in its cohesiveness, permeability and refractory qualities. In addition to Albany sand, this concern mines and ships all other grades of molding sand from fine brass and aluminum sands to core sands, clays and gravels.

HAND TACHOMETERS.—In a four-page circular, issued by Schuchardt & Schutte, 90 West street, New York, a new hand tachometer is illustrated and described. It combines a hand tachometer and cutmeter, being equally convenient for indicating rotative as well as progressive speed. It indicates, without the aid of a stop watch, the revolutions of steam engines, gas engines, motors, etc., as well as the cutting speeds of milling machines, engine lathes, planers, drilling machines, etc. By the aid of this instrument, belt slipping can be immediately detected.

CENTRIFUGAL PUMPS.—A recent bulletin issued by Henry R. Worthington, 115 Broadway, New York City, is devoted to centrifugal pumps for low-head service. This type was designed to meet the large demand for a reliable pump which may be purchased at a low price, and is especially suitable for pumping out excavations, coffer-dams and for small irrigation plants. A table is included, showing several combinations of engine-driven pumps, and many other combinations can be made to suit special conditions. Another bulletin illustrates and describes house and sump pumps.

METALLOGRAPHIC LABORATORY SUPPLIES.—Sauveur & Boylston, Cambridge, Mass., have issued a catalog which describes and illustrates their line of apparatus for research work in metallography. The outfit recommended as including all the essential parts required by the metal microscopist, follows: One metallurgical stand with two eye-pieces and three objectives, one vertical illuminator, two stage specimen holders, one auxiliary tube and one copy of "Manipulation of the Microscope," by Edward Bausch. A number of special instruments for the laboratory are also described. In view of the increased recognition of metallurgy as a practical means for determining the physical characteristics of the various metals, the catalog is of unusual interest.

TROPENAS CONVERTERS.—An exceedingly valuable 52-page pamphlet, which describes the Tropenas process of steel manufacture in detail, has been issued by the Tropenas Converter Co., 50 Church street, New York City. The manufacture of steel castings is discussed at length and attention is directed to the advantages of the converter process. A large number of illustrations are included, showing installations in all sections of the United States and numerous illustrations of converter steel castings are also shown. The drop bottom converter, a recent development, is also described, as well as such steel foundry equipment as sand grinders and mixers, ladle heaters, etc. The catalog also contains a large number of testimonial letters from concerns manufacturing steel by the Tropenas converter process.

STEEL SASH.—Lupton's steel sash and Pond continuous sash and operating devices, as well as other specialties, are illustrated and described in a 36-page catalog, issued by the David Lupton's Sons Co., Philadelphia. The specialties made by this concern include a complete line of steel sash, skylights and operating devices that entirely cover the field of natural lighting and ventilation. The counterbalanced type of steel sash manufactured by this concern, is designed for foundries, forge shops and factories requiring a large amount of ventilation. The large lights of glass are easily cleaned and the sash, when open, does not project beyond the wall line. In addition to the details of constructive and standard forms of steel sash, views are given of a large number of interesting installations in large plants throughout the country. These include not only power houses, foundries, etc., but industrial plants of a widely diversified character.

CRANES.—Wrecking, locomotive, construction, pillar and hand power cranes, as well as pile drivers, transfer tables, portable rail sawing machines and clam shell buckets, are illustrated and described in a handsome, 80-page catalog, issued by the Industrial Works, Bay City, Mich. The line of cranes built by this concern is designed to meet all needs and requirements from large wrecking or construction cranes of a lifting capacity of 120 tons, down through a long line of hoisting apparatus to the hand power cranes of one ton maximum capacity. These numerous types of lifting machines cover the entire field of portable steam, electric and hand power station cranes. These include locomotive cranes, propelled by their own power, as well as stationary cranes of every size and description. The illustrations are particularly interesting in that they show wrecking cranes at work, as well as the application of lifting devices for various uses.

GENERAL INDUSTRIAL NOTES

The Nashua Machine Co., Nashua, N. H., has taken over the Bundy department of the American Radiator Co.

The Gurney Electric Elevator Co., Hones-Pa., announces its succession to the business of the National Elevator & Machine Co., of that place.

The Savill-Chandler Co., Canton, Ill., has been re-incorporated with a capital of $150,000 and will hereafter be known as the Canton Foundry & Heating Co.

The foundry of the Taylor Steel Co., Plain City, O., has been leased by the Steel Products Co., a recently incorporated concern, and has been placed in operation.

The Penn Foundry & Mfg. Co., Basic City, Va., has been incorporated with a capital of $120,000. The incorporators are A. F. Holliday, J. A. Patterson and S. C. Dally.

The Brinnis Mfg. Co., Oxnard, Cal., has recently been incorporated for the purpose of operating a foundry in connection with the present machinery business of Louis Brinnis.

The Wabash Foundry & Machine Co., Wabash, Ind., has been incorporated with a capital stock of $50,000. The incorporators are A. B. Rowley, J. I. Robertson and others.

The Troy Foundry Co., Troy, O., has been incorporated with a capital of $10,000. The incorporators are J. W. Merkle, Jacob Lust, L. H. Shipman, G. Miller and Louise E. Eichts.

The Globe Iron Works, Stockton, Cal., will remove its plant to Sacramento, where construction work has already been begun on a pattern shop, machine shop, foundry and several other buildings.

The Cleveland Aluminum Casting Co., Cleveland, has been incorporated with a capital of $100,000. The incorporators are Fred F. Klingman, M. J. Hancox, R. S. Hoffman, A. A. Winkle and Jos. F. Prosser.

The Kibbe-Workinger Foundry Co., Elkhart, Ind., has been incorporated with a capital of $20,000 and will operate a jobbing foundry and machine shop. The incorporators are O. E. Kibbe, Z. G. Kibbe and E. M. Workinger.

The Franklin Foundry Co., Franklin, Pa., recently organized, will operate a gray iron jobbing foundry. The melting equipment consists of a Whiting cupola of nine tons hourly capacity, which will be operated by a positive pressure blower.

J. F. Newell & Co., Gardiner, Me., have been incorporated under the firm name of the J. E. Hodgkins Co., and will continue the manufacture of trolley wheels, bearings for electric railway motors, journal brasses, and miscellaneous iron and brass castings.

The Tacoma Foundry & Machine Co., Tacoma, Wash., recently incorporated with a capital of $50,000, has purchased 2½ acres of land upon which it will erect a large foundry. The incorporators are John Taylor, T. B. Hall and Wilson Webb, the latter being shop superintendent.

The Connelly Steel Casting Co., Chelsea, Mass., recently incorporated with a capital of $5,000, has purchased the plant of the Lundin Steel Casting Co., Chelsea, and will continue the business as in the past. The officers of the new company are James Connelly, president; J. Ashman, treasurer, and A. Munroe, secretary.

The James Foundry Co., Clyde, O., has completed the erection of its new plant. The buildings consist of a foundry, 60 x 80 feet, of cement block construction; cleaning shop, 25 x 32 feet; pattern shop, 20 x 40 feet; machine shop, 50 x 200 feet; power plant, 16 x 16 feet, and sand and coke sheds 12 x 65 feet. The greater part of the equipment has been installed.

The S. J. Gardner Foundry & Machine Co., New Albany, Ind., has taken over the shops of S. J. Gardner and has erected the following buildings: Machine shop, 50 x 120 feet; sheet iron shop, 60 x 120 feet; foundry, 50 x 120 feet. The officers of the company are S. J. Gardner, president; M. C. Gardner, vice president, and Frank S. Sissloff, secretary and treasurer.

The Western Steel & Iron Co., Ltd., Winnipeg, Can., has succeeded the Western Iron Works, Ltd., of that city with a considerable increase in resources and will engage in the manufacture of ornamental and architectural iron work, forgings, castings, railroad and contractors' materials, etc. The officers of the company are C. F. Simpson, president, and A. Simmers, vice president.

New Construction.

The M. Hertenstein Co., Columbus, O., is erecting a two-story addition to its foundry.

Henry H. Martin, Louisville, Ky., will shortly erect a foundry at 201 North Cabel street.

The Skinner Engine Co., Erie, Pa., is erecting a new foundry which will triple its present output.

The Star Foundry Co., Albert Lea, Minn., is erecting a new foundry, 60 x 100 feet, at Waterloo, Ia.

The Thomas Mfg. Co., Springfield, O., contemplates the erection of an addition to its gray iron foundry.

The Hunt-Spiller Mfg. Corp., Boston, contemplates the erection of an addition to its foundry, 40 x 100 feet.

The G. E. Hoglund Foundry Co., Gardner, Mass., is erecting a foundry, 40 x 100 feet, of steel and concrete construction.

The Georgia School of Technology, Atlanta, Ga., will erect a foundry, blacksmith shop and administration building, at a cost of $50,000.

The Buckeye Iron & Brass Works, Dayton, O., are erecting an iron foundry, 83 x 160 feet, which will be ready for occupancy about Aug. 1.

The Crescent Stove Works, Evansville, Ind., has now under course of construction a new foundry, 71 x 171 feet, which will increase its present capacity 100 per cent.

The Sheridan Iron Works, Sheridan, Wyo., will erect a new plant, of brick construction, which will include a foundry for the manufacture of gray iron, brass and aluminum castings.

The Muskegon Steel Castings Co., Muskegon, Mich., a recently incorporated concern, is erecting a building, 64 x 90 feet, which will include a foundry for the manufacture of steel castings.

The Banner Mfg. Co., Ferdinand, Ind., is erecting a building 40 x 88 feet, which will comprise a foundry and machine shop. A Whiting cupola and other foundry equipment have been installed.

The West Steel Foundry Co., Cleveland manufacturer of converter and crucible steel castings, will erect a large extension to its main building to provide additional molding and cleaning facilities.

The Aransas Foundry, Machine & Boiler Works, Aransas Pass, Texas, are erecting a new plant consisting of a foundry, 40 x 75 feet, machine shop, 40 x 80 feet and a blacksmith and boiler shop, 50 x 75 feet.

The Taylor & Boggis Foundry Co., Cleveland, will erect a new plant including a foundry, 112 x 420 feet, a builders' hardware manufacturing department, 111 x 270 feet, a pattern storage building, 50 x 200 feet, and an office building, 51 x 135 feet.

The Waterloo Malleable Iron Co., Waterloo, Ia., is now building the third addition to its works. The foundations are laid for a building, 90 x 100 feet, which will be rushed to completion, as the additional floor space is badly needed to care for contracts now on hand.

The Geo. White & Sons Co., Ltd., London, Ont., has under construction a new plant, covering five acres, which will include a foundry, 75 x 280 feet. This concern will engage in the manufacture of gray iron castings and will install a number of molding machines in its foundry.

John Westover, Inc., Lincoln, Neb., has removed to its new plant, which consists of a structural shop, 80 x 100 feet; foundry, 50 x 80 feet; blacksmith shop, 50 x 100 feet; office building, 20 x 34 feet, three stories high, in addition to other buildings, such as pattern shop, pattern storage shed, coke and sand sheds, etc.

The L. W. Pond Machine & Foundry Co., manufacturer of gray iron castings, Worcester, Mass., will erect an addition to its present plant, consisting of a foundry, 100 x 245 feet, of brick and steel construction, at an estimated cost of $75,000. New equipment will be installed, including two cupolas, three electric traveling cranes, a blower and other foundry equipment.

The H. B. Smith Co., Westfield, Mass., manufacturer of radiators, boilers and other heating specialties, has awarded the contract for several new buildings to increase the capacity of its plants. The new structures will consist of a machine shop, 100 x 100 feet, two stories high; a foundry, 100 x 245 feet, which will adjoin the present foundry; a coremaking shop, 80 x 100 feet, and a steel frame storehouse. The machine shop and foundry extension will be built of brick and structural steel and the core department will be of concrete.

Among the Brass Founders.

The Acme Brass Foundry Co., Los Angeles, Cal., has been incorporated with a capital of $30,000 by F. K. Czerniski, S. F. Margozewith and others.

The Standard Brass Casting Co., Oakland, Cal., is completing the erection of a new plant at Third and Jefferson streets, which includes a foundry, 100 x 100 feet.

The Nipissing Foundry & Machine Co., North Bay, Ont., has been succeeded by the North Bay Iron Wire & General Metal Works. This concern will engage in the manufacture of iron, brass and aluminum castings.

The Buffalo Aluminum & Bronze Co., Buffalo, has been incorporated with a capital of $25,000 and will engage in the manufacture of brass and aluminum castings. The incorporators are G. W. Morris, J. G. Papell and E. G. Northrup.

C-R-A-N-E-S

Whiting Cranes meet all requirements of service, safety and accessibility. Minimum cost of operating and upkeep.

"FOUNDRY CRANES BY FOUNDRY PEOPLE"

FOUNDRIES

DESIGNED : EQUIPPED : INSTALLED

FOR ALL CLASSES OF CASTINGS

Our experts available at reasonable charge to assist starting Steel (O. H. and Converter), Malleable and Iron Foundries.

SEND FOR CATALOGS

Sales Agencies

NEW YORK, Wonham, Sanger & Bates, 30 Church St.
PITTSBURG, Samuel W. Hay's Sons, 1415 Keenan Bldg.
CINCINNATI, S. Obermayer Co.
ST. PAUL, Robinson, Cary & Sands Co., 4th & Wacouta Sts.
RICHMOND, VA., Smith - Courtney Co.
BIRMINGHAM, ALA., Dewstoe Machine Tool Co., Brown-Marx Bldg.
DENVER, Hampson-Fielding Engr. Co., 1711 Tremont St.
WASHINGTON, D. C., H. A. Gillis, Home Life Bldg.
SALT LAKE CITY, F. E. Arnold, Atlas Block.

WHITING
FOUNDRY EQUIPMENT CO.
HARVEY-ILL. U. S. A.
CHICAGO SUBURB.

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Sales Agencies

SEATTLE, WASH., Caldwell Bros. Co., 1014 First Ave., South
SAN FRANCISCO, Henshaw-Bulkley & Co., 19 Fremont St.
MONTREAL, Dominion Foundry Supply Co., 47 Murray St.
WINNIPEG, J. A. McTaggart & Co.
EDMONTON, ALTA., Gorman, Clancey & Grindley Co.
MEXICO CITY, Mexican Steel Products & Machinery Co.
MONTEREY, MEX., Sanford & Cia.
LONDON, ENG., J. W. Jackman & Co., Ltd., Caxton House, West
PHILADELPHIA, PA., J. Jacob Shannon & Co., 1744 Market St.

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Put This New Steel Rack Into Your Factory

It has advantages that you never before believed possible — advantages that will make it fit right into your factory system and prove double the value of any rack or shelving you've ever used before.

THIS BERGER STEEL RACK

stands alone—it needs no bracing to floor, wall or ceiling,—it is absolutely independent. It is made stiff and rigid by its unique design and construction.

The Berger Steel Rack will stand even a heavier load—a more severe test than the photograph shows. It will readily and easily hold more men but we wanted you to get a little glimpse of the rack itself.

The shelves are adjustable to different heights and locations—adaptable exactly to suit your needs.

Put these racks into your plant—try them—prove their genuine merit, their real advantage to you.

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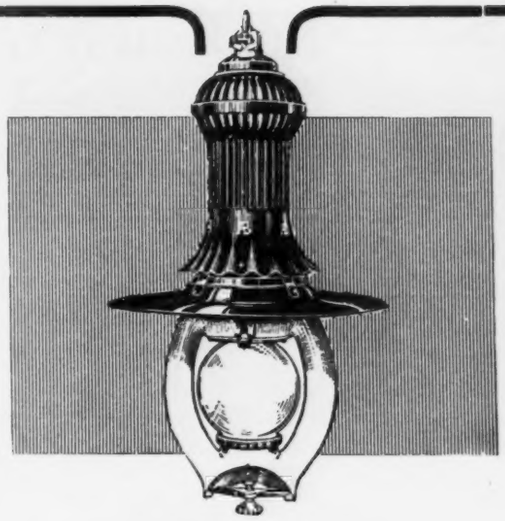
We also manufacture a full line of shop shelving complete with Compartment Divisions, Bin Boards, Open Shelving that is independent of any outside support, Tote Boxes, etc.



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Needs Little Attention

The A-B Regenerative Flame lamp requires trimming only once in seventy hours. Its carbons last three to four times as long as those in the ordinary flame lamp and it is but a moment's work to renew them when exhausted.

The A-B Regenerative Flame Lamp

is especially fitted for use in the foundry where lamps which need attention every day would be impracticable.

Its mechanism is very simple. Turning a single screw adjusts the lamp for trimming. There are no moving parts to clean and the slight carbon deposit on the globe is easily removed with a brush which comes with the lamp.

With A-B lamps in your foundry your lighting system will require little attention. You will pay less for carbons, use less current and still have the best foundry light it is possible to produce.

Write now for our Bulletin No. 98. It contains valuable information on lighting the foundry.

The Adams-Bagnall Electric Company

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Montreal

CLASSIFIED ADVERTISEMENTS

Help Wanted Positions Wanted
Advertisements under these heads 50c for 25 words including address. Each additional word 2c.

Business Opportunities Miscellaneous, etc.
Advertisements under these heads cost 25c a line. Count seven words to the line.

CASH MUST ACCOMPANY ORDER

In answering advertisements it is advisable to state whether foundry is Gray Iron, Malleable or Brass

Help Wanted

FOREIGN MANUFACTURERS OF VERY complete line of sandblast machinery want an experienced salesman to take charge of entire American business. Offices in New York. Commission and drawing account. A rare chance for the right man to build up a substantial income. Write fully stating previous experience, references, etc. All answers treated confidentially. Box 285, THE FOUNDRY, Cleveland, O.

FOUNDRY SUPPLY SALESMAN WANTED to sell the best core oil in the country as a side line in Chicago and vicinity. Address Box 162, THE FOUNDRY, Cleveland, O.

FIRST CLASS FOUNDRY FOREMAN wanted, thoroughly competent to handle small castings, plow points and moldboards. Must understand molding machines. To be thoroughly reliable and honest. Address Box 308, THE FOUNDRY, Cleveland, O.

WANTED — FOREMAN THOROUGHLY experienced on automobile cylinder castings. State full particulars and references, which will be treated strictly confidential. Must be first class man. Address Box 281, THE FOUNDRY, Cleveland, O.

FOUNDRY FOREMAN WANTED, thoroughly familiar with the manufacture of aluminum castings, particularly aluminum ware. Should have experience in the mounting of patterns for this line of work and should be familiar with the melting of aluminum. Address Box 314, THE FOUNDRY, Cleveland, O.

FOUNDRY CHEMIST WANTED. AN experienced man familiar with mixtures of iron in a foundry doing miscellaneous jobbing work, including green, dry sand and loam, with capacity of 40 tons per day. Located in vicinity of New York. State experience and salary expected. Address Box 298 THE FOUNDRY, Cleveland, O.

MAN TO TAKE CHARGE OF MOLDing machines, one accustomed to valves, fittings, etc. Must give reference and name of last employer. Address Box 295, THE FOUNDRY, Cleveland, O.

MOLDERS—TWO FIRST-CLASS NON union loam molders, good pay. Address Box 267 THE FOUNDRY, Cleveland, O.

WANTED — SEVERAL EXPERIENCED wheel molders. Don't apply unless you are able to keep losses below 1%. Steady work. Good job. Nice location in small town south. Open-shop. Address "Moulder," THE FOUNDRY, Cleveland, O.

WANTED—FOUR NON-UNION CORE makers experienced in automobile work. Steady work and good wages. Address Box 272, THE FOUNDRY, Cleveland, O.

WANTED—TWO NON-UNION EXPErienced floor molders in automobile aluminum work. Steady work and good wages. Address Box 273, THE FOUNDRY, Cleveland, Ohio.

WANTED—ONE GOOD EXPERIENCED coremaker in brass foundry in Chicago. Address Box 300, THE FOUNDRY, Cleveland, O.

WANTED—A MAN EXPERIENCED IN adapting of patterns to squeezers and machines, also the making of match plates. State experience, age, and give references. Address Box 296, THE FOUNDRY, Cleveland, O.

WANTED—WORKING FOREMAN TO take charge of small brass foundry. Must be familiar with light bench work and one experienced in mixing scrap preferred. State wages desired and furnish references. Address Box 250, THE FOUNDRY, Cleveland, O.

Help Wanted

FOREMAN CORE MAKER—MAN ACcustomed to valves, fittings, etc. Give reference, age and with whom last employed. Address Box 315, THE FOUNDRY, Cleveland, O.

CORE MAKERS—FOR GREEN SAND on valves, fittings, etc. Address Box 316, THE FOUNDRY, Cleveland, O.

MOLDER—MAN TO TAKE CHARGE OF molding machines. Address Box 317, THE FOUNDRY, Cleveland, O.

MAN WANTED TO TAKE CHARGE OF shipping and cleaning room in iron foundry. Must have experience and have good executive ability. Good position for the right man. Address Box 301, THE FOUNDRY, Cleveland, O.

COMPETENT MAN WANTED FOR SOIL pipe work. Must have practical experience and give satisfactory reference. Address "Soil Pipe," THE FOUNDRY, Cleveland, O.

FIRST CLASS PATTERN MAKER AND draftsman for general foundry work. Must have practical experience and able to give good reference. Address "C. F. M. C.," THE FOUNDRY, Cleveland, O.

PIPE SHOP FOREMAN WANTED FOR Southern foundry. Good salary to the right party. Address "K," THE FOUNDRY, Cleveland, O.

WANTED — FOREMAN FOR SHEET metal department of large plant experienced on gas range work. One who has the ability to handle men and capable of producing results. Splendid opportunity for the right man. Address Box 309, THE FOUNDRY, Cleveland, O.

AN EXPERIENCED MAN WANTED TO take charge of Tabor, Mumford and Hand Squeezer Machines. Good wages and steady employment to the right man. Address P. O. Box 2026, Paterson, N. J.

Positions Wanted.

POSITION WANTED AS SUPERINtendent or general foreman of malleable foundry. I have 23 years of practical experience on all classes of malleable castings. On the floor, bench, match plate and machine molding. Melting furnaces and annealing ovens, and can handle men to get results. Held position of general foreman of large malleable foundry for about 10 years. Address Box 310, THE FOUNDRY, Cleveland, O.

POSITION WANTED AS FOUNDRY foreman in Ohio. Twenty-five years' practical experience. Experienced in machine molding, green sand, dry sand, skin dry, loam or bench molding, cupola practice, mixing of iron, heavy or light work all through, large or small castings. Have ability to get results, produce the goods, and am well up in the modern ways of handling men. Can furnish good reference. Address Box 297, THE FOUNDRY, Cleveland, O.

A MIDDLE AGED FOUNDRY FOREman, German, of wide experience in all engine, architectural and jobbing work with A-1 references of noted firms, up-to-date in foundry practice, can handle men to satisfaction, desires a position in or near Los Angeles, Cal., on account of family matters. Address Box 304, THE FOUNDRY, Cleveland, O.

CHEMIST COLLEGE GRADUATE; AT present engaged, desires change, had experience in cupola-converter management. Thoroughly experienced in the analysis of all foundry materials, mixing metals and blowing heats. Excellent references. Address Box 289, THE FOUNDRY, Cleveland, O.

Positions Wanted

POSITION AS GENERAL FOREMAN IN foundry making light castings. Long experience as a practical man on stoves, gas ranges, heaters and light work generally. Floor and bench, gated work and match plates. Expert on molding machines and match plate equipment. Up-to-date in cupola practice. I can handle men to good advantage and produce results. Open shop preferred. A-1 references furnished. Address "Result-Getter," THE FOUNDRY, Cleveland, O.

AN EXPERIENCED AND RELIABLE foundry foreman wishes to communicate with some reliable firm that may be in need of a general foundryman, up-to-date in all branches of a foundry. Address Box 258, THE FOUNDRY, Cleveland, O.

POSITION WANTED AS FOREMAN patternmaker by a man of first-class ability and experience in all kinds of gas, steam engine and general work. Best of references. Open shop preferred. Address Box 179, THE FOUNDRY, Cleveland, O.

POSITION WANTED AS FOREMAN OF gray iron foundry. Experienced in heavy and light work, and molding machines, mixing by analysis. Good executive and cost reducer. Address Box 264, THE FOUNDRY, Cleveland, O.

WANTED POSITION AS FOUNDRY SUperintendent, malleable or grey iron. Address Box 286, THE FOUNDRY, Cleveland, O.

NON-UNION MOLDER SEEKS POSItion on loam or dry sand, had 18 years experience engine or jobbing work. Address Box 256. THE FOUNDRY, Cleveland, O.

FOUNDRY SUPERINTENDENT OR foreman wishes to correspond with firm looking for such. Married, strictly temperate and up to the minute in modern methods. Address Box 279, THE FOUNDRY, Cleveland, O.

FOUNDRY FOREMAN DESIRES A POition with reliable firm; 20 years experience on heavy and light machinery, gas engine, structural and ornamental iron and bronze of highest grade. Familiar with molding machines and A-1 cupola practice. I can furnish the best of references as to character and abiiity. Open shop preferred. Address Box 276, THE FOUNDRY, Cleveland, O.

POSITION WANTED AS FOUNDRY foreman in malleable or gray iron foundry. Up-to-date in foundry practice, 28 years experience, married, strictly temperate, experienced on molding machines, open shop preferred. Address Box 175, THE FOUNDRY, Cleveland, O.

MR. FOUNDRYMAN: — HAVING trouble in your foundry? Are you seeking certain results? Have you anyone to whom expert foundry knowledge will be invaluable? Let me solve the problem with my thirty years of concentrated practical experience. Have my own foundry. Special offer this month. Write today. James W. DuBois, foundry consultant. Cold-Spring-on-Hudson, N. Y.

HAVE YOU A GRAY IRON FOUNDRY in or near Chicago you wish filled up with a desirable class of well paying business I wish to connect with a large foundry, who can take on and take care of additional steady work. Eight years experience, steady and willing worker, good references. I have a job as general manager but am looking for a position as sales manager. Address Box 271, THE FOUNDRY, Cleveland, O.

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Positions Wanted

FOUNDRY FOREMAN OPEN FOR POSITION July 1st, wishes to correspond with firm requiring sober, energetic foundryman to take charge of shop, doing heavy medium and light work. Can handle green men and get results. Open shop south or west preferred. Good references. Address Box 265, THE FOUNDRY, Cleveland, O.

FIRST CLASS CORE FOREMAN, 37 years of age, wishes position in grey iron or malleable foundry. Am an expert core maker, well experienced in mixing different sands, and overcoming all difficulties in the foundry caused by cores. Address Box 318, THE FOUNDRY, Cleveland, O.

POSITION WANTED AS GENERAL foreman of stove and furnace works. Reliable, experienced foundryman. Can handle the manufacturing end of all departments of medium size plant and guarantee results. Thoroughly understand stove and furnace construction. A practical executive and work to employer's interests. Address Box 319, THE FOUNDRY, Cleveland, O.

POSITION WANTED BY A FIRST-class up-to-date stove and range metal patternmaker. Familiar with any work in that line. Special on stove pattern, core and match plate work. Address "O. K. Patternman," THE FOUNDRY, Cleveland, O.

UP-TO-DATE FOUNDRY SUPERIN-tendent, now employed, desires change where ability will be appreciated. Best reasons for wanting to change, with A-1 reference. Address Box 306, THE FOUNDRY, Cleveland, O.

POSITION AS GENERAL FOREMAN OF gray iron foundry. Thoroughly practical and up-to-date in the latest methods. Understand molding machines thoroughly. Best of reference. Address Box 313, THE FOUNDRY, Cleveland, O.

FOUNDRY FOREMAN, AGE 33, SOBER, energetic, wishes position with firm manufacturing first class malleables. 14 years' practical experience. Can handle men to advantage, also used to molding machines, etc. Good references if necessary. At present employed. Address Box 312, THE FOUNDRY, Cleveland, O.

POSITION WANTED AS FOREMAN, 12 years' experience as same on medium weight castings. Can mix, handle help, machines, and look after good sized shop. Address Box 311, THE FOUNDRY, Cleveland, O.

FOUNDRY SUPERINTENDENT, experienced in radiator and boiler work, desires position with a progressive manufacturer desirous of reducing operating costs. Also experienced in general foundry work. Address Box 302, THE FOUNDRY, Cleveland, O.

POSITION WANTED AS FOUNDRY foreman by a competent malleable man up-to-date on molding machines. Best of references. West or middle West preferred. Address Box 303, THE FOUNDRY, Cleveland, O.

POSITION WANTED AS FOUNDRY SU-perintendent by a man of wide experience in gray iron work. Thoroughly familiar with molding machine practice and general knowledge of foundry work. Will insure great economies in operating costs. Position desired should be one of responsibility where intelligent effort will be appreciated and compensated. Address Box 307, THE FOUNDRY, Cleveland, O.

ENERGETIC YOUNG MAN, AMBI-tious and not afraid of hard work, with five years' experience with wholesale and retail hardware interest. Would consider position in store or stock room. No objection to location. Best references. Address Box 320, THE FOUNDRY, Cleveland, O.

Positions Wanted

POSITION WANTED AS SUPERINTEND-ent or general foreman by a thoroughly up-to-date practical man. Am familiar with all departments connected with foundry using modern methods. Am a married man, 40 years of age, sober and able to furnish best of references as to character and ability in handling men and producing results. Address Box 58, THE FOUNDRY, Cleveland, O.

Business Opportunities

WANTED—FOREMAN FOR JOBBING iron foundry to take financial interest and have entire charge of the business. Good buildings, equipment and plenty of work. Address Box 293, THE FOUNDRY, Cleveland, Ohio.

FOR SALE—FOUNDRY AND MACHINE shop in western Illinois, doing good business in structural iron and general casting. Owner wishes to retire. Address Box 252, THE FOUNDRY, Cleveland, O.

FOR SALE:—VERY CHEAP. A COM-pletely equipped modern foundry and machine shop. Foundry equipped with two fifteen ton traveling cranes, 42-inch Whiting cupola, pneumatic chippers, and all machinery in both foundry and machine shop equipped with individual motors. The property includes main shop 35 x 170 feet, with ell 50 x 70, coreroom 25 x 50, hydraulic elevator to lift iron and coke to charging floor. Plant completely remodeled and overhauled less than two years ago. Well located in town adjacent to one of the largest casting markets; two railroads and water transportation. Owners engaged in other business and have no time to devote to this property. An exceptional proposition will be made to the right man. Address Box 284 THE FOUNDRY, Cleveland, O.

FOR SALE:—WELL EQUIPPED GRAY iron foundry and machine shop 15 miles from Chicago. Working at present. Object of selling short of capital. Good opportunity and no reasonable offer will be refused. Address Box 270, THE FOUNDRY, Cleveland, Ohio.

La SOCIETE ANONYME des ETABLIS-sements Ph. Bonvillain & E. Ronceray, 9 and 11 Rue des Envierges, Paris (France), announce that they have bought back the Patent right for the Universal System of Machine Moulding, also their System of Pattern Plate Making. They are ready to consider offers from a reliable American firm to handle this line of equipment, which has been greatly improved during the past 12 months. The Universal System has been applied at a considerable extent abroad for making moulds for all kinds of castings from those weighing a few ounces to several tons.

PARTNER WANTED—A PRACTICAL foundry man with $3,000 to $5,000 to take superintendence of foundry of ten to twelve-ton capacity per day; good location; want to start a foundry; have three-ton business per day to commence. Box 23, Bradley, Ills.

MAKE MACHINE MOLDING A SUC-cess in your foundry, especially jar-ramming. I am a practical foundry superintendent and have made a very wide range of small, large, thick and thin, plain, irregular and under-rammed castings. This has cost years of experience and more than $100.00 was expended experimentally. If you propose using or are now using jarring machines and have these or other problems unsolved, I can save you money. Tell me your troubles. Address Box 299, THE FOUNDRY, Cleveland, O.

Business Opportunities

FOR SALE—ONE-THIRD INTEREST IN small foundry and machine shop in Colorado, good chance for a molder who wishes to get into Colorado. Address Box 305, THE FOUNDRY, Cleveland, O.

PATTERN MAKING. THE BEST EQUIP-ped pattern shop in Northwestern Ohio. Wood or metal patterns of all kinds. First class workmen. Best work guaranteed. Your patronage is solicited. The Superior Iron & Mfg. Co., Wauseon, Ohio.

AGENCY WANTED. WE HAVE A first-class office, centrally located, where we can show an excellent display of a manufacturer's product and represent him in first-class shape, we cover the trade and the manufacturer having a good staple line will find it to his advantage to communicate. Fort Dearborn Sales Co., Room 304, 180 N. Dearborn St., Chicago, Ill.

Miscellaneous

FLUOR SPAR—EVERY GRADE, QUOTA-tions delivered anywhere. Cheapest suppliers. Address GEO. G. BLACKWELL SONS & CO., Ltd., Liverpool, Eng., or Agents, Penna. Salt Mfg. Co., Pittsburg, Pa.

FOR SALE—ONE NO. 1 SLY CINDER mill, good as new, used but very little. Can offer a good bargain on this. Write Witte Iron Works Co., Kansas City, Mo.

BLOWER BARGAINS: ROOT'S SEC-ond-Hand Blowers, bought, sold, or exchanged for new ones. Address H. M. Papworth, 120-122 Liberty Street, New York City.

USE PAXSON'S "FILL-IN" STEEL CE-ment. For covering up blow holes, scars and defects in castings, making joints and permanently stopping leaks in steam, water, air and gas pipes. Made by J. W. Paxson Co., Philadelphia.

SECOND-HAND FOUNDRY EQUIPMENT wanted, including Cupolas, Ladles, Tumbling Barrels, etc. Quote price and state condition. Address Box 885, THE FOUNDRY, Cleveland, O.

FOR SALE—A COLLIAU CUPOLA FUR-nace, 23 inches inside of lining. Air blower and pipings. It has been used only two weeks. Address John Werner Machine Works, 713, 729 Lake Ave., Rochester, N. Y.

FOR SALE—1 NO. 10, 1½" STEEL shell iron cinder mill, the W. W. Sly Mfg. Co.'s make. Address Union Sanitary Mfg. Co., Noblesville, Ind.

FOR SALE—A SMALL SECOND HAND cupola in good condition. Utica Heater Company, 92½ Lafayette St., Utica, N. Y.

FOR SALE: ONE EXHAUST CLEAN-ing mill, W. W. Sly make, diameter 48", length 68", door opening 21½" x 52"; thickness of shell ¼", in first class order. Will sell at very low price. Address The F. A. Klaine Company, Cincinnati, Ohio.

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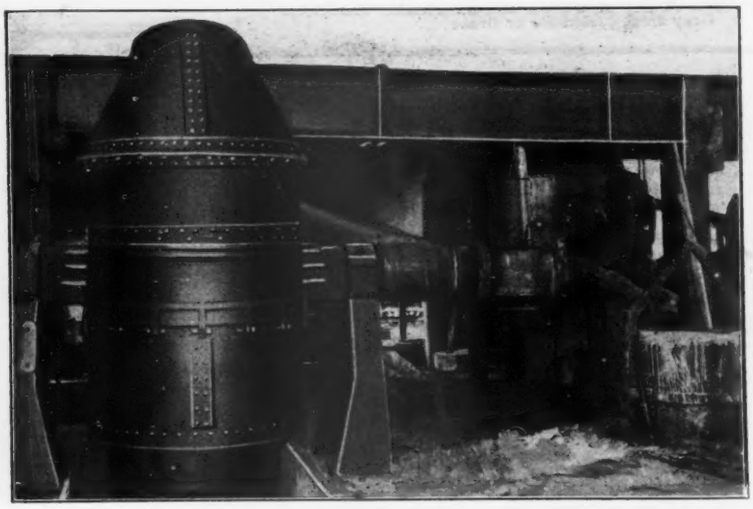

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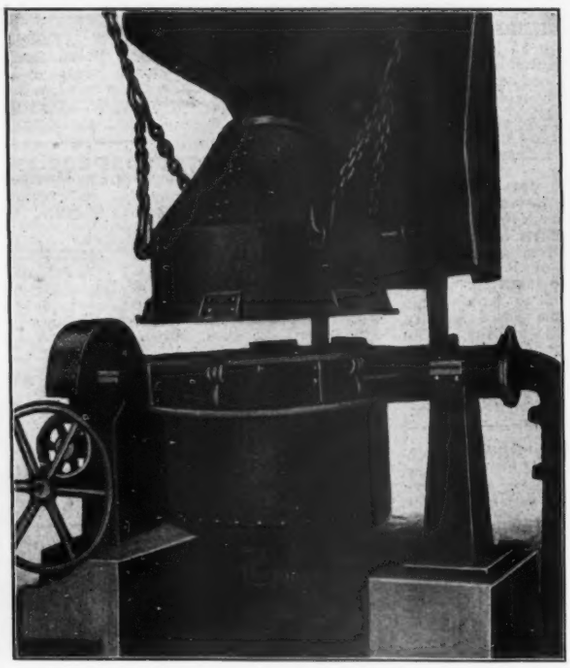

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COMPLETE STEEL CASTING PLANTS DESIGNED, ERECTED AND OPERATED BY EXPERTS WITH YEARS OF EUROPEAN AND AMERICAN EXPERIENCE.

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